

U.S. Department of Energy

**Radionuclide Air Emissions
Annual Report**

Calendar Year 1998

**Rocky Flats Environmental
Technology Site**

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Radionuclide Air Emissions Annual Report for Calendar Year 1998

Prepared in accordance with
40 CFR 61, Subpart H
and
CAQCC Regulation No. 8, Part A, Subpart H

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EXECUTIVE SUMMARY

As required by Title 40 of the Code of Federal Regulations (CFR), Part 61, Subpart H, and Colorado Air Quality Control Commission Regulation No. 8, Part A, Subpart H, the radiation dose to the public from the Rocky Flats Environmental Technology Site (Site) is determined annually and reported to the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment. These regulations limit the air pathway dose from Site activities to any member of the public to an annual effective dose equivalent (EDE) of 10 millirem (mrem).

For comparison, the average annual EDE for residents of the Denver area from all sources of radiation is approximately 420 mrem, over 80% of which is due to natural background radiation (Roberts, 1998). The health risk associated with 1 mrem of EDE from naturally occurring sources of background radiation (such as uranium or thorium in rock or soil, cosmic rays, and radon emitted from soil or bedrock) is the same as that produced from anthropogenic sources of radiation, such as Site activities or medical x-rays.

Compliance with the 10 mrem standard has been determined by comparing environmental radionuclide air concentration measurements at critical receptor locations with the "Concentration Levels for Environmental Compliance" listed in Table 2 of Appendix E to 40 CFR 61. Compliance is demonstrated when each measured radionuclide air concentration is less than its corresponding compliance level in Table 2 and when the "fractional sum" of all radionuclides is less than 1. For 1998, each measured radionuclide air concentration was less than 1% of its corresponding compliance level and the fractional sum of all radionuclides was less than 1.5% of the allowable level at all sampling locations. The Site was in compliance with the 10 mrem standard during 1998.

Airborne radionuclides appear to have been dominated by naturally occurring uranium isotopes in 1998. At the receptor with the largest fractional sum, for example, uranium isotopes characteristic of naturally occurring uranium represented an order-of-magnitude larger dose than that contributed by nonuranium isotopes.

In addition, the locations of maximum measured radionuclide levels did not match the location of maximum impact due to Site activities (directly east of the Site). Instead, the locations where the highest total radionuclide levels were measured in 1998 (northwest and southeast of the Site) were influenced by off-Site activities that generated dust, such as traffic or quarrying operations. These patterns are consistent with those seen from sampling results in 1997.

For comparison, the 1998 air dose due to Site activities was also calculated using the EPA-approved CAP88-PC dispersion model, as has been done in previous years. The dose was calculated for the most impacted off-Site individual. The calculated EDE for the 1998 calendar year to this maximally exposed individual was 0.041 mrem, which is

less than 0.5% of the standard. Individuals living or working at other off-Site locations received a lower dose. Because the emission estimates and modeling methods used were based on "worst case" assumptions, the actual maximum off-Site dose for 1998 is expected to be lower than the calculated value.

The modeling analysis results suggest that the Site activity that contributed most to off-Site dose in 1998 was the draining of the Building 788 clarifier tank. However, it is likely that the modeling analysis overestimated the true contribution of this project to off-Site dose. The pre-project emission estimates that were used in the modeling analysis relied on extremely conservative assumptions regarding contamination levels and tank draining methods. In contrast to the dose level predicted by the model, project-specific monitoring in the vicinity of the tank draining activities showed radionuclide levels near background concentrations for the duration of the project. For comparison, the total modeled dose due to all other sources at the Site (excluding the Building 788 clarifier tank) totaled 0.0032 mrem, while the clarifier tank was modeled at 0.038 mrem by itself.

Because no nuclear weapons-related processing has occurred at the Site since 1989, the majority of radionuclide emissions result from decontamination and remediation of building materials, soil, and debris. As cleanup of the Site continues, the Site air emission and dose profile will be dominated by projects that disturb contaminated materials, soil, or debris. In many cases, these cleanup activities will involve much smaller amounts of radionuclides than are stored or handled inside Site buildings. However, the nature of remediation and other cleanup activities is such that emissions cannot be managed to the same extent as emissions from activities taking place under controlled conditions inside structures.

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Abbreviations and Acronyms

Am	Americium
APEN	Air Pollutant Emission Notice
ASRF	Advanced Size Reduction Facility
Ave	Avenue
Blvd	Boulevard
Bq	Becquerel(s)
CAP88-PC	Clean Air Act Assessment Package-1988 (Version 1.0)
CAQCC	Colorado Air Quality Control Commission
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci/m ³	Curies per cubic meter
Ci/yr	Curies per year
cm	Centimeter(s)
cm ²	Square centimeters
dpm	Disintegrations per minute
DOE	U.S. Department Of Energy
DOT	U.S. Department of Transportation
E	East
EDE	Effective dose equivalent
EIS	Effluent Information System
ENE	East-northeast
EPA	U.S. Environmental Protection Agency
ESE	East-southeast
GPC	Gas Proportional Counting
GIS	Geographic information system
H-3	Tritium
HEPA	High efficiency particulate air (filter)
Hwy	Highway
IHSS	Individual Hazardous Substance Site
kg	Kilograms
km	Kilometer(s)
km ²	Square kilometer(s)
kPa	KiloPascals
LLW	Low-level waste
m	Meter(s)
m ²	Square meter(s)
m ³	Cubic meters(s)
MDA	Manual Disassembly Area
MEI	Maximally exposed individual
mrem	Millirem

Abbreviations and Acronyms (continued)

m/s	Meters per second
mSv	MilliSievert(s)
N	North
NE	Northeast
NESHAP	National Emission Standards for Hazardous Air Pollutants
NNE	North-northeast
NNW	North-northwest
NW	Northwest
OASIS	Organic and Sludge Immobilization System
ODIS	Off-Site Discharge Information System
PAM	Proposed Action Memorandum
PIDAS	Perimeter Intrusion Detection and Assessment System
Pu	Plutonium
RAAMP	Radioactive Ambient Air Monitoring Program
RCRA	Resource Conservation and Recovery Act
Rd	Road
rem	Roentgen equivalent man
RFCA	Rocky Flats Cleanup Agreement
RFEC	Rocky Flats Engineers and Constructors, L.L.C.
RFFO	Rocky Flats Field Office
RMRS	Rocky Mountain Remediation Services, L.L.C.
S	South
SE	Southeast
SIP	Sampling and Inerting Pad
Site	Rocky Flats Environmental Technology Site
SNM	Special nuclear material
SRS	Savannah River Site
SSE	South-southeast
SSW	South-southwest
SS&C	Sand, Slag, and Crucible
St	Street
Sv	Sievert(s)
SW	Southwest
T-1	Trench 1
TRU	Transuranic
U	Uranium
USC	United States Code
VOC	Volatile organic compound
W	West
WIPP	Waste Isolation Pilot Plant
WNW	West-northwest

Abbreviations and Acronyms (continued)

WSW	West-southwest
μm	Micrometer(s)
°C	Degrees Celsius

1.0 INTRODUCTION

The Rocky Flats Environmental Technology Site (Site) is subject to *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities* (Title 40 of the Code of Federal Regulations [CFR], Part 61, Subpart H).

Regulation 40 CFR 61, Subpart H, applies to operations at any facility owned or operated by the U.S. Department of Energy (DOE) that emits radionuclides (other than radon-222 and radon-220) into the air. The standard requires that emissions of radionuclides to the ambient air from the Site not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 millirem (mrem) (0.1 milliSieverts [mSv]). Colorado has incorporated 40 CFR 61, Subpart H, by reference as Colorado Air Quality Control Commission (CAQCC) Regulation No. 8, Part A, Subpart H.

Regulation 40 CFR 61, Subpart H, Section 61.94, requires the Site to determine compliance with the standard for the previous calendar year and to submit this information, along with other data, to the U.S. Environmental Protection Agency (EPA) in an annual report (CAQCC Regulation No. 8, Part A, Subpart H, requires submittal to the Colorado Department of Public Health and Environment [CDPHE]). This report fulfills the reporting requirements of 40 CFR 61.94 and CAQCC Regulation No. 8, Part A, Section 61.94, for the 1998 calendar year.

In 1997, DOE filed an application with EPA and CDPHE requesting approval of an alternate compliance demonstration method for 40 CFR 61, Subpart H (DOE, 1997a). The alternate method is based on environmental measurements of radionuclide air concentrations at critical receptor locations, rather than dispersion modeling. In cases where nonpoint sources of emissions are the primary contributors to dose, as has been the case at the Site since 1995, such a sampling-based alternative method is recommended by EPA (EPA, 1991).

The alternate compliance demonstration method uses a portion of the Site's Radioactive Ambient Air Monitoring Program (RAAMP) network, which consists of ambient air samplers placed around the Site perimeter and at other locations of interest. CDPHE approved the proposed alternate method in 1997 (Fox, 1997). In 1998, EPA approved the method with conditions, which included the installation of two additional RAAMP samplers to the north and northeast of the Site and the relocation of one existing RAAMP sampler (Rushin and Clough, 1998).

Because the majority of the compliance demonstration samplers were in place during 1998, compliance has been determined using the alternate method for this annual report. For comparison, compliance has also been determined using the standard modeling approach, as agreed to with EPA.

2.0 FACILITY INFORMATION

This section describes the Rocky Flats Environmental Technology Site, lists the radioactive materials used at the Site, and describes the handling and processing that the radioactive materials undergo. New construction or modifications in calendar year 1998 for which construction approval and startup notification were waived per 40 CFR 61.96 are also identified in this section. Construction approval and startup notification were not required for any new construction or modifications in 1998.

2.1 Site Description

The Rocky Flats Environmental Technology Site is operated by Kaiser-Hill Company, L.L.C., with oversight by the Rocky Flats Field Office (RFFO) of the U.S. Department of Energy. Prior to 1989, the Site fabricated nuclear weapons components from plutonium (Pu), uranium (U), beryllium, and stainless steel. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic (TRU) radionuclides, and related quality control functions. Plutonium weapons operations were curtailed at the Site in 1989 due to safety concerns, and in February 1992, the Site's weapons production mission was discontinued. The Site is now undergoing decontamination, decommissioning, and cleanup and is moving toward final closure.

The Site occupies an area of 26.5 square kilometers (km²) in northern Jefferson County, Colorado, about 25.7 kilometers (km) northwest of Denver. The Site is located at approximately 1,829 meters (m) above mean sea level on the eastern edge of a geological bench known locally as Rocky Flats. This bench, about 8.1 km wide in an east-west direction, flanks the eastern edge of the Rocky Mountains.

Over 2.1 million people live within 80 km of the Site. Adjacent land use is a mixture of agriculture, open space, industry, and residential housing. Surrounding communities include the city of Golden to the south of the Site; the cities of Arvada, Broomfield, and Westminster to the east; and the city of Boulder to the north. An area map is shown in Figure 2-1.

The former production facilities are located near the center of the Site within a fenced security area of 1.6 km². The remaining Site area contains support facilities and serves as a buffer zone for former production facilities. A map of the Site is shown in Figure 2-2; a simplified map of the central portion of the Site (the "industrial area") showing the location of the former production facilities is shown in Figure 2-3.

The central portion of the Site, which houses the former production facilities, can be roughly divided into halves. The Protected Area, generally located in the northern half of the central area (see Figure 2-3), historically housed plutonium processing operations.

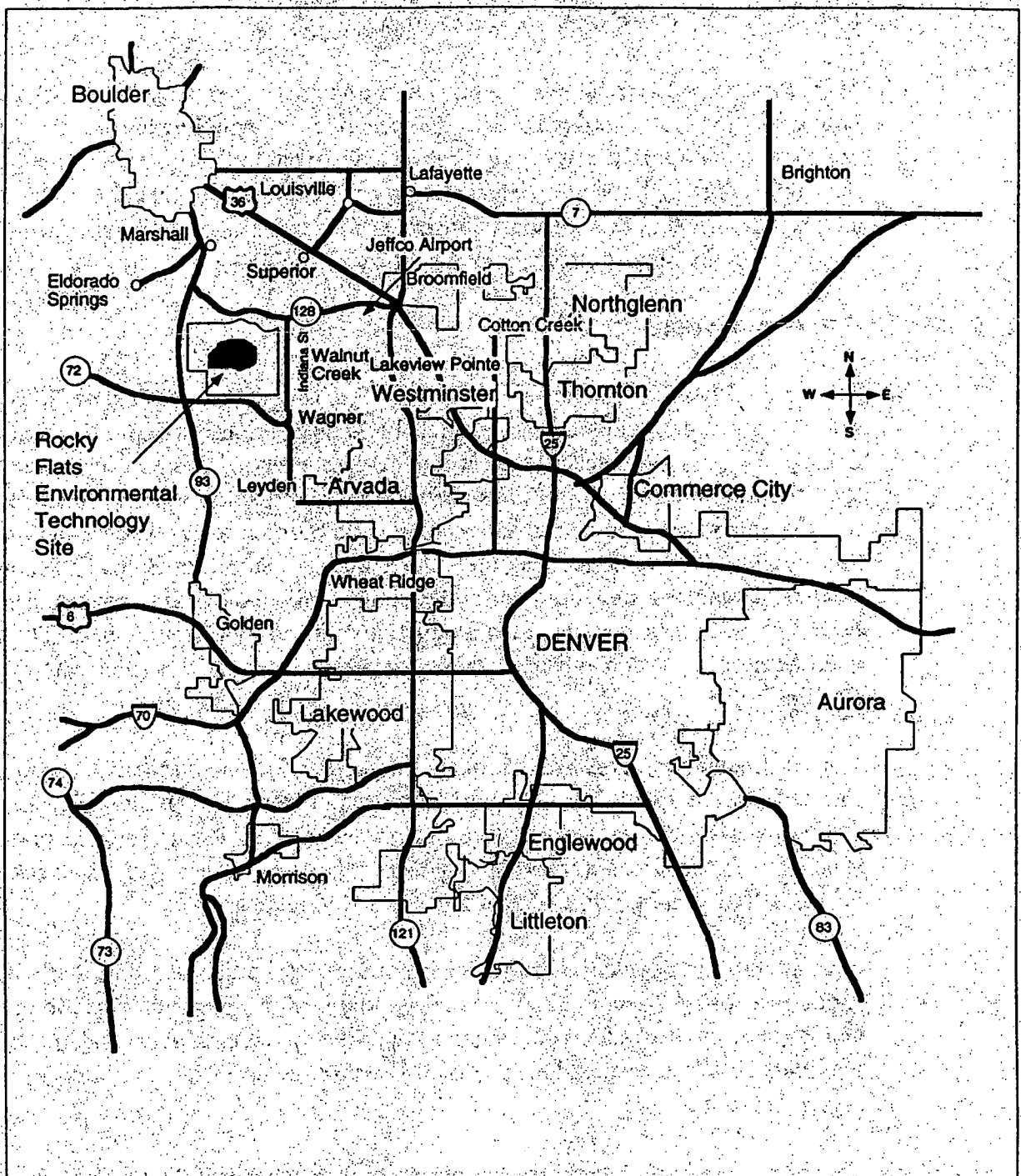


Figure 2-1. Area Map of the Rocky Flats Environmental Technology Site and Surrounding Communities

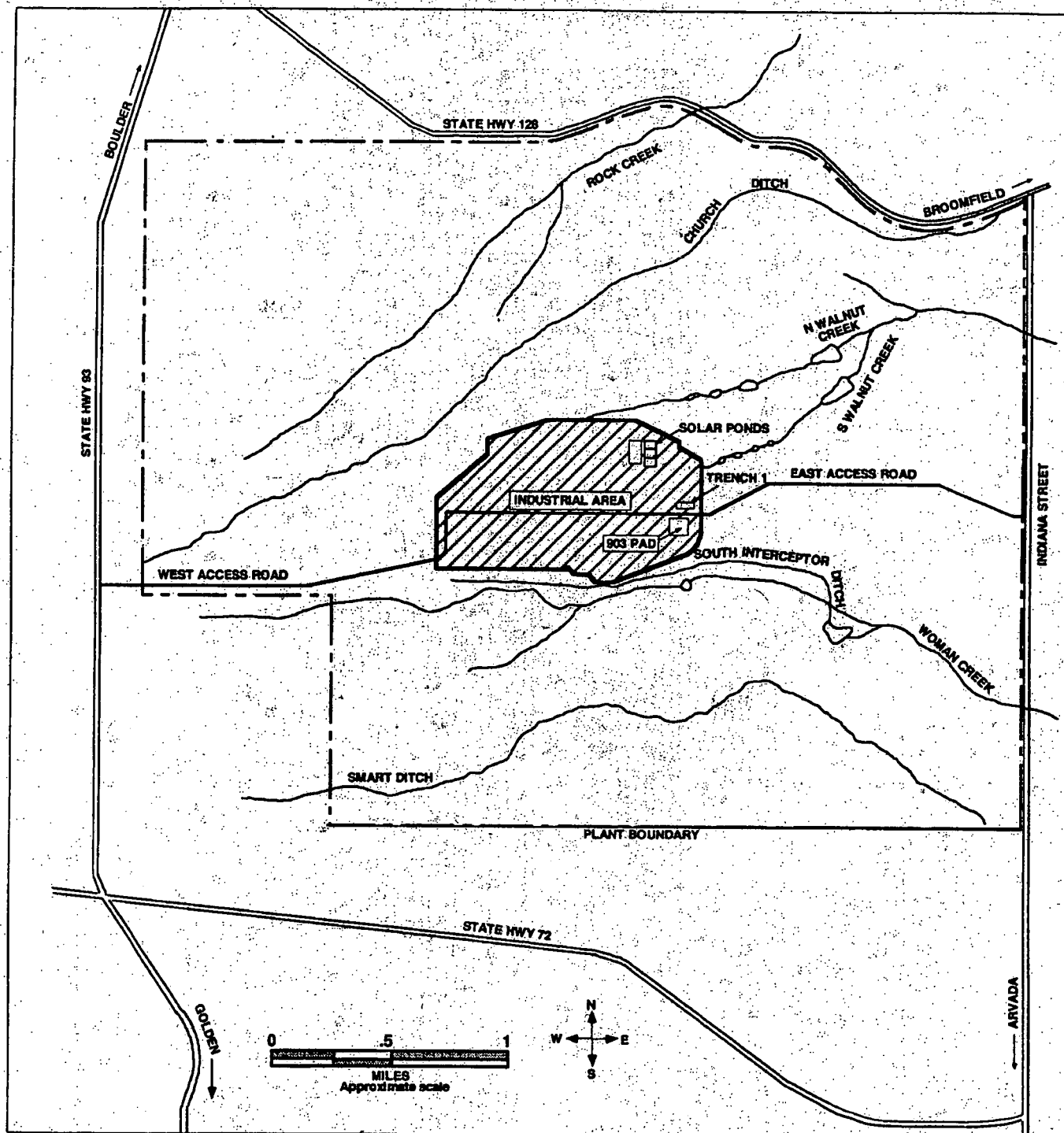


Figure 2-2. Rocky Flats Environmental Technology Site Location Map

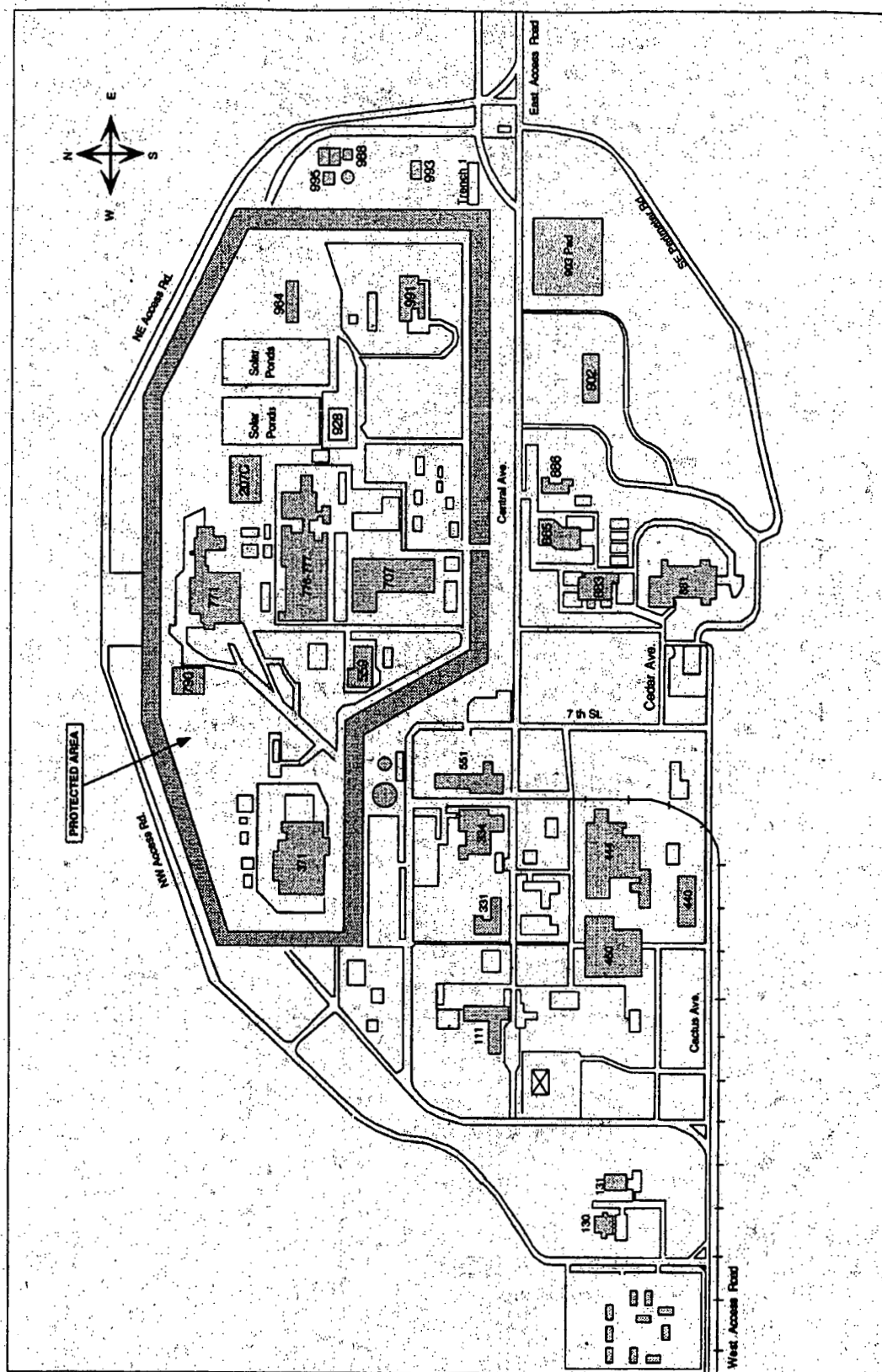


Figure 2-3. Central Portion of the Rocky Flats Environmental Technology Site (Industrial Area)

The rest of the industrial area was involved with uranium, beryllium, and stainless steel operations.

2.2 Radionuclide Air Emissions Source Description

Radioactive material handling at the Site is currently focused on material consolidation, cleanup, radioactive residue stabilization, waste processing, and analytical operations. Most of the radionuclide air emissions from the Site result from nonpoint (diffuse) sources, primarily mechanical and natural disturbances of contaminated soil. Soil contamination was caused by past radioactive material spills and other releases. In addition, the soils on and around the Site contain small quantities of naturally occurring radionuclides.

Radioactive material processing can result in radionuclides becoming entrained in ventilation air (effluent) that is released through vents or stacks (point sources). However, because no routine nuclear weapons-related processing has occurred at the Site since 1989, the majority of radionuclide point source emissions result from the resuspension of residual radioactive material in ventilation systems and from decontamination and deactivation activities taking place in process buildings.

Air exhausted from process buildings is cleaned prior to release by passing it through multiple stages of high efficiency particulate air (HEPA) filters. As a result, radionuclide point source emissions from the Site are very low.

2.2.1 Radioactive Materials Handling and Processing in Calendar Year 1998

In 1998, radionuclide emissions from the Site occurred from several activities that either disturbed resident contamination in buildings or in soil, or that processed or used radionuclide-containing substances such that emissions to the atmosphere resulted. Appendix A lists radioactive materials associated with the Site. The list of radionuclides includes Pu-239/240, americium (Am)-241, U-233/234, U-235, U-238, and tritium. The Site also has some small quantities of beta- and gamma-emitting sealed sources and low activity analytical stock solutions, powders, and plated sources; emissions from these sources were negligible.

The major Site activities and sources that handled or processed radionuclides in calendar year 1998, with resulting radionuclide emissions, are described below.

Hold-up in Ducts

Radionuclide emissions were generated through disturbance of radionuclide-contaminated dust and other deposits on the surfaces of ventilation ducts exiting process areas. These materials were deposited on duct walls and in rapidly decreasing amounts

on the successive stages of HEPA filters during many years of weapons component production. Routine air movement and pressure changes in the ducts entrain a small amount of this contamination on an ongoing basis. In addition, decontamination and equipment removal or reconfiguration activities disturbed a portion of the hold-up in certain ducts in 1998, resulting in additional emissions to the atmosphere. Ducts containing hold-up were vented through multiple stages of HEPA filters.

Resident Contamination

In some process areas, contamination may be found on glovebox surfaces and floors, and, in limited cases, in the rooms themselves. This contamination has been surveyed and estimated using surface swipes in the areas. As with hold-up, resident contamination was emitted in 1998 due to routine exposure to ventilation air and due to active disturbance by project activities, particularly decontamination and equipment movement. Ducts venting areas with significant contamination were exhausted through multiple stages of HEPA filters.

Consolidation of Special Nuclear Material (SNM)

SNM is plutonium and enriched uranium contained in weapons components, metals, metal alloys, and oxides. Consolidation activities related to SNM continued in calendar year 1998 and included metal brushing, size reduction of metal, thermal stabilization of oxide, and packaging and interim storage of SNM. These consolidation activities are defined as follows:

- Metal brushing: Mechanical removal of metal oxide from metal surfaces.
- Size reduction: Reduction of material size by breaking, cutting, sawing, or pressing to accommodate storage container requirements.
- Thermal stabilization of oxide: Treatment of unstable forms of metal oxides in furnaces operating in the range of 800 to 1,200 degrees Celsius (°C) to remove moisture and to fully oxidize the metal to stable form.
- Packaging and storage: Placement of material in approved, inert atmosphere, storage containers, which in turn are placed in "storage vaults" or "vault-type rooms." Storage vaults are repositories of SNM materials that satisfy required safety and risk criteria.

Consolidation activities resulted in radionuclide emissions in 1998 through exposure of SNM to ventilation air, as well as through mechanical and thermal disturbance of SNM. Consolidation was performed in areas where ventilation air was exhausted through HEPA filters.

Waste Handling

Most of the low-level, low-level mixed, and TRU waste materials at the Site were generated during plutonium weapons component production and radionuclide recovery operations conducted prior to 1989. In 1998, some solid waste forms, including contaminated gloveboxes and duct work, were segregated and size reduced prior to packing for storage and disposal. Such activities disturbed the radioactive contamination in the waste, resulting in radioactive particles in the room air.

Radioactive wastes were handled (segregated, size reduced, and packaged) inside buildings or other structures. Venting the air through HEPA filters controlled emissions from these operations.

In addition to solid waste forms, liquid waste in tanks and pipes may also release radionuclides to the atmosphere, either through routine passive venting, or when liquid waste is exposed to the atmosphere when systems are drained or the materials treated. In addition to routine emissions from tank vents, liquid waste movement projects in several buildings contributed to emissions during 1998. These activities all took place in areas that vented through HEPA filters.

Waste Storage

Packaged low-level, low-level mixed, and TRU wastes are commonly stored in drums at various locations on the Site. In 1998, drums were vented to prevent pressure buildup from hydrogen gas generated as a product of radiolytic activity affecting packaged materials. While hydrogen is routinely vented, radionuclide emissions would only occur from these drums if the inner packaging failed. To minimize emissions should the inner packaging fail, the drums were equipped with small filter cartridges that functioned like HEPA filters. For purposes of estimating emission potential for compliance with 40 CFR 61, Subpart H, the packaged materials inside these drums were considered sealed sources (in accordance with Appendix D to 40 CFR 61).

Waste Repackaging

Radionuclide emissions were generated in 1998 from waste characterization and repackaging activities that are ongoing at the Site in support of proposed waste shipment plans. Proposed shipment plans required the characterization and repackaging of various radionuclide-contaminated waste ashes and residues in preparation for shipment and final disposition at either the Savannah River Site (SRS) or the Waste Isolation Pilot Plant (WIPP). All of the waste repackaging activities that occurred in 1998 took place in areas that were vented through HEPA filters.

Remediation Projects

As cleanup of the Site continues, remediation activities also contribute to the resuspension of contaminated soils and debris. Remediation projects at the Site are performed in accordance with the Rocky Flats Cleanup Agreement (RFCA). RFCA is a negotiated, interagency agreement governing Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) cleanup activities at the Site. RFCA defines Tier I and Tier II action levels based on concentrations of various contaminants in the water or soil, where contamination above the higher Tier I action levels suggests cleanup may be necessary, while contamination above Tier II represents contaminant concentrations that require further evaluation.

In 1998, remediation activities at the Site included excavation and handling of contaminated soil, debris, and depleted uranium drums, as well as heavy equipment traffic, primarily from the Trench 1 (T-1) source removal project and installation of a collection and treatment system associated with the Mound Site Plume. Emissions from these activities were controlled using dust suppression techniques and, for T-1, a weather shelter.

Miscellaneous Point Sources

In late 1997, several laboratory operations were transferred from Buildings 881 and 123 to a new modular laboratory. The modular analytical laboratory continued operations in 1998, with low-level radionuclide emissions from the handling of contaminated media (such as filters). The modular analytical laboratory is described in more detail in Section 2.2.2.

Miscellaneous Nonpoint Sources

Another contributor to Site radionuclide emissions in 1998 was the resuspension of contaminated soils. Contaminated soils were resuspended by wind erosion, vehicle traffic, and other mechanical soil disturbances not directly associated with specific remediation projects. Emissions generated by wind erosion were uncontrolled, while radionuclide emissions from vehicle traffic and mechanical disturbances were generally controlled using dust suppression techniques.

In addition to the resuspension of contaminated soils, two other miscellaneous nonpoint sources contributed to Site radionuclide emissions in 1998. The first was a drum crushing operation initiated in 1996 within the Protected Area that continued through 1998. This operation created small amounts of radionuclide emissions by disturbing low levels of radiological contamination on the drum surfaces. This operation was described in the calendar year 1996 annual report (DOE, 1997b). The second nonpoint source

involved emptying the clarifier tank located at the edge of Building 788. Using a high-pressure spray to dislodge sludge, the tank was emptied and the sludge pumped from the clarifier into smaller tanks that were transported to the 750 Pad for storage.

2.2.2 New Construction and Modifications in Calendar Year 1998

Eighteen new or modified activities that contributed to the Site air pathway dose are described below. (Emissions used in calculating the 1998 off-Site dose, as well as the location for each activity, are discussed in Sections 3.0 and 4.0 of this report.)

As part of the project evaluation process, the maximum annual (controlled) off-Site EDE that could result from each new or modified activity was calculated to determine approval and notification requirements. Maximum potential radionuclide emissions were estimated using emission and control factors from Appendix D to 40 CFR 61, combined with information regarding radionuclide contaminant levels and material forms, radionuclide release mechanisms, and the radionuclide emission controls employed. In cases where HEPA filters were employed, credit was taken for a maximum of two stages, although up to four stages may actually have been employed. Emissions were modeled using the Clean Air Act Assessment Package-1988 (CAP88-PC), Version 1.0, and recent Site meteorological data to estimate annual EDEs at the most impacted off-Site residence and business locations. For emissions that were subsequently sampled and measured, the measured radionuclide concentrations were used to calculate the 1998 air pathway dose, as described in Sections 3.0 and 4.0 of this report.

The detailed data and calculations used to develop emission estimates and resulting dose projections are maintained in Site files. The project- or process-specific EDEs used in making regulatory applicability decisions regarding approval requirements are reported below.

To place the reported EDE values in context, it should be noted that the emission estimation and modeling methods used in this exercise are designed to generate "worst case" dose estimates. The emission factors, control device efficiencies, and modeling approach are mandated by 40 CFR 61, Appendix D, to ensure that project dose will not be underestimated. In fact, actual emissions and dose will often be much lower than the estimates used to determine approval and notification requirements.

With one exception, the estimated EDE (shown below) for each new construction or modification was less than 1% of the 10 mrem (0.1 mSv) standard, and construction approval and startup notification were unnecessary under 40 CFR 61.96. The exception was the T-1 source removal project, which had an estimated EDE of 9.7×10^{-1} mrem (9.7×10^{-3} mSv), which represents 9.7% of the standard. However, the T-1 source removal project was undertaken in accordance with CERCLA. For CERCLA projects, the administrative requirements of other regulations, including requirements for

preconstruction approval or notification, are replaced by the CERCLA decision document process.

Building 123 Decommissioning: Building 123 was decommissioned and demolished in 1998. Radionuclide emissions were expected to be negligible based on the previous usage of the building as an analytical laboratory. However, early in 1998 radiological contamination was found in Room 105. The contamination was in a cabinet under a laboratory hood.

The contaminated panels, hood, cabinets, sink, and floor grating were removed. During strip-out, it was discovered that the concrete slab was contaminated with a beta-emitting isotope. The area was immediately remediated. All contaminated waste was bagged and disposed of as low-level waste.

The maximum annual off-Site EDE was calculated using the worst-case dose survey and the assumption that all the square footage remediated was contaminated at that worst-case concentration. Emissions were estimated assuming 18.6 square meters (m^2) were contaminated at a level of 600,000 disintegrations per minute (dpm) (beta) per 100 square centimeters (cm^2). The emission factors for this activity were taken from 40 CFR 61, Appendix D. Effluent from this activity was vented through one stage of HEPA filters. Based on the above information, the maximum annual (controlled) off-Site EDE from the Room 105 strip-out was estimated to be 3.1×10^{-11} mrem (3.1×10^{-13} mSv).

Glovebox Removal in Building 779: The 1998 activities in Building 779 involved the removal and size reduction of gloveboxes, B-boxes, and hoods in areas venting to Plenums 404 and 405. Prior to removal and size reduction, a stripcoat decontamination material was applied to the equipment surfaces to reduce the contamination levels. The stripcoat decontamination material controlled 90% of the potential emissions of removable contamination and material hold-up on the surfaces by binding and removing contaminant particles or by sealing them to the equipment surfaces. Effluent streams were vented through two stages of HEPA filters.

The off-Site EDE from this activity was calculated based on the average amount of Pu-239 holdup in the boxes, the total area of the cuts, and radionuclide emission factors from Appendix D to 40 CFR 61. The following maximum annual (controlled) off-Site EDEs were estimated: Plenum 404, 8.07×10^{-7} mrem (8.07×10^{-9} mSv) and Plenum 405, 5.40×10^{-7} mrem (5.40×10^{-9} mSv). The total off-site EDE from these activities was estimated to be 1.3×10^{-6} mrem (1.3×10^{-8} mSv).

Thermo NUtech Modular Analytical Laboratory: Late in 1997, a new, stand-alone modular laboratory facility was constructed in the 902 Pad area. A description of this operation was not included in the calendar year 1997 annual report and is presented here instead. However, the emissions from the operations performed in this laboratory were accounted for in 1997 as emissions from Buildings 123 and 881, as explained below.

The modular laboratory is used to analyze material samples and perform radiological counting in support of Site remediation projects and routine operations. Thermo NUtech performs operations that were formerly handled in Buildings 123 and 881 including Gross Alpha by Gas Proportional Counting (GPC); Radiological Screening by GPC; Gross Alpha/Beta by GPC; Air Filter Counting by Air Filter Counting System; Tritium Activity in Bubblers by Liquid Scintillation Counting, and Ambient Filter Loading, Unloading, and Composite Preparation. The change was initiated to allow the operations in Buildings 123 and 881 to be terminated and the facilities decommissioned. Building 123 has since been demolished.

Estimated off-Site impacts from the Thermo NUtech operations are negligible, well below the 10 mrem (0.1 mSv) standard. This determination was based on the estimated inventory of radioactive materials that are handled in the laboratory and the operation of similar facilities. Except for the waste storage area, which vents through a HEPA filter, radionuclide emissions from the modular laboratory are uncontrolled.

Building 771 High-Level Dissolution System Draining: This project involved draining System 7, a high-level dissolution system in Building 771. The system contained plutonium nitrate solutions and had a total capacity of 65 liters.

Activities associated with the System 7 draining project exhausted through four stages of HEPA filters to a vent that was continuously sampled for radionuclide air emissions. The off-Site dose estimate was based on the total amount of liquid drained, the concentration of plutonium in the liquid, and emission factors for liquids obtained from 40 CFR 61, Appendix D. The maximum annual (controlled) off-Site EDE resulting from the Building 771 dissolution system draining was estimated to be 3.3×10^{-5} mrem (3.3×10^{-7} mSv).

Building 371 Repackaging of Sand, Slag, and Crucible (SS&C) Ash

Residue: During 1998, repackaging of sand, slag, and crucible ash was conducted in Building 371 to prepare the SS&C material for shipment to SRS for treatment. Approximately 3,000 kilograms (kg) of material was size reduced and repackaged for shipment. The ash material had been stored in other buildings at the Site.

The size reduction and repackaging of the ash occurred in the Room 3602 gloveboxes in Building 371. Drums containing the ash were opened in the downdraft table enclosure and checked for contamination and radiation. The individual containers of interest were removed from the drums and moved into the glovebox repackaging area. Each container was opened and the material was size reduced and divided into batches of appropriate weight and plutonium content. These batches were subsequently repackaged into cans and bagged out of the glovebox. Following assaying, the cans were packaged in Department of Transportation (DOT)-approved containers.

The gloveboxes in Room 3602 exhausted through four stages of HEPA filters, through a vent that was continuously sampled for radionuclide emissions. The off-Site EDE was calculated based on the known total plutonium content in the materials and the process rate. The emission factors used were from Appendix D to 40 CFR 61, Subpart H. The maximum annual (controlled) off-Site EDE from these activities was estimated to be 6.6×10^{-5} mrem (6.6×10^{-7} mSv).

LECO™ Crucible Repackaging in Building 776 Glovebox: LECO™ crucibles are ceramic containers approximately 2.5 centimeters (cm) in length and diameter, formerly used for carbon analyses of plutonium metals and oxides. The waste LECO™ crucibles were packaged in either 4-liter plastic containers or 1-gallon (3.8-liter) paint cans, which were placed in 55-gallon (208-liter) residue drums.

In 1998, the crucibles were repackaged in Building 776 for potential shipment to WIPP in New Mexico. The 55-gallon drums of crucibles were transferred to the Building 776 Manual Disassembly Area (MDA) of the Advanced Size Reduction Facility (ASRF). Each drum was moved to the glovebox, where the lids were removed and the entire drum contents were lifted into place at the bag-in port. The drum contents were then poured or pulled into a bag and a second bag was placed over the first. Crucibles were then placed into TRU waste drums.

The effluent from this activity was exhausted through four stages of HEPA filters, through a vent that was continuously sampled for radionuclide emissions. The maximum annual (controlled) off-Site EDE resulting from the Building 776 LECO™ crucible repackaging project was estimated to be 9.3×10^{-5} mrem (9.3×10^{-7} mSv). The EDE calculation was based on the total plutonium content of the LECO™ crucibles and the rate of the repackaging process, and used 40 CFR 61, Appendix D emission factors.

LECO™ Crucible Repackaging in Building 707, Module K: LECO™ crucibles were also repackaged in a glovebox in Module K in Building 707. The 55-gallon drums of crucibles were transferred to Module K. The LECO™ crucibles were poured out of the existing paint cans for visual inspection inside the glovebox. Foreign material was removed and the crucibles were put back into the paint can. Any deteriorated cans were replaced. Crucibles were then placed into TRU waste drums.

The maximum annual (controlled) off-Site EDE resulting from the LECO™ crucible repackaging project in Building 707 was estimated to be 9.3×10^{-5} mrem (9.3×10^{-7} mSv). The effluent from gloveboxes in Module K was exhausted through four stages of HEPA filters, through a vent that was continuously sampled for radionuclide emissions. The EDE estimation for this activity was based on the total plutonium content of the materials and the repackaging process rate, and used 40 CFR 61, Appendix D emission factors.

Dry Residue Repackaging in Building 776: Prior to 1992, the primary mission of the Site was to produce plutonium components for nuclear weapons as part of the overall

national defense program. The handling of plutonium and plutonium compounds during manufacturing and recovery operations produced a wide variety of contaminated by-products. Dry residues are one category of these by-products. The dry residues were repackaged to meet waste acceptance criteria for potential shipment to WIPP.

Dry residues packaged in 55-gallon drums were transferred to the MDA of the ASRF in Building 776. Each drum was moved to the glovebox, where the lids were removed and the entire drum contents were lifted into place at the bag-in port. The drum contents were then poured or pulled into a bag and a second bag was placed over the first. Residues were then placed into TRU waste drums.

The glovebox in the ASRF exhausted through four stages of HEPA filters, through a vent that was continuously sampled for radionuclide emissions. The maximum annual (controlled) off-Site EDE resulting from the dry residue repackaging project was estimated to be 9.7×10^{-5} mrem (9.7×10^{-7} mSv). This dose calculation was based on the activity process rate and the total plutonium content of the dry residues, and used emission factors from 40 CFR 61, Appendix D.

RCRA Stabilization of Building 774 Tanks: Twenty storage tanks in Building 774 containing RCRA wastes were treated in 1998. Initially each tank contained a small amount of waste oil. The waste oil was consolidated into two tanks, leaving 18 empty tanks. Roughly 2.3 cubic meters (m^3) of waste oil mixed with trichloroethane and contaminated with plutonium were then treated with the Organic and Sludge Immobilization System (OASIS).

Based on the plutonium concentration of the oil transferred to these tanks between October 18, 1988 to January 12, 1990, and using a ratio of oil to trichloroethane, the maximum annual off-Site EDE for the tank stabilization project was estimated to be 6.8×10^{-2} mrem (6.8×10^{-4} mSv). The tanks and the OASIS system exhausted through HEPA filters to a continuously sampled vent. The EDE for this project was calculated using the conservative assumption that the OASIS process operated three times longer than it actually took to process the waste oil. Emissions were estimated using emission factors from Appendix D to 40 CFR 61.

Building 776, Process Waste Tanks: The four process waste tanks in Building 776, Room 127 were evaluated for air quality issues in 1998. These four tanks vent through a one-stage HEPA filter to the atmosphere. The vent is a passive outlet system that is not sampled for radionuclides. The total combined design capacity of the four tanks is 22.2 m^3 . Dose calculations assumed that the tanks contained 22.2 m^3 of waste material contaminated with plutonium at the maximum measured concentration seen in sampling data going back to 1995. Emission factors from Appendix D to 40 CFR 61 were used.

The maximum annual (controlled) off-Site EDE resulting from the four process waste tanks was estimated to be 1.8×10^{-5} mrem (1.8×10^{-7} mSv).

Building 788 Clarifier Tank: The clarifier tank located at the edge of Building 788 was emptied of Solar Pond sludge in 1998. The clarifier is an open-top tank with a capacity of 113.6 m³ and contained roughly 62.5 m³ of water and sludge.

The sludge was pumped from the clarifier into 110 smaller tanks. A high pressure (20,684 kiloPascals [kPa]), hot water (60°C) submerged sprayer was used to loosen the sludge for pumping. The smaller tanks were then transported to the 750 Pad, where they are stored.

The maximum off-Site EDE was estimated based on the volume of liquid in the tank as well as the maximum radionuclide concentration of that liquid. The emission factor was based on Appendix D to 40 CFR 61 with an added factor for conservatism because high pressure water sprayers were used. The estimated maximum annual off-Site EDE was 3.9×10^{-2} mrem (3.9×10^{-4} mSv) (there were no radionuclide emission control devices associated with this project).

Building 371 Loading Dock: In 1998, a new loading dock was constructed and placed into operation on the west side of Building 371. Approximately 1,147 m³ of soil were removed from the construction area due to surface excavation and pier drilling. The soil was relocated to an open area.

Prior to project operation, soil samples were collected and analyzed for radioactive isotopes. Results of the analysis showed radionuclide concentrations consistently two to four orders of magnitude below applicable RFCA Tier II soil action levels.

Dose calculations for this project were based on the conservative assumption that all the soil handled would contain the maximum concentrations of radionuclides measured from soil samples, as documented in "Sample Results Summary" of the *Soil Management Plan* (Rocky Flats Engineers and Constructors, L.L.C. [RFEC], 1997). Based on this contamination level and emission factors from Appendix D to 40 CFR 61 and an EPA reference document (EPA, 1995), the maximum annual off-Site EDE was estimated to be 5.4×10^{-4} mrem (5.4×10^{-6} mSv) (no radionuclide emission controls were employed for this project).

Cathodic Protection Installation for the North Perimeter Intrusion Detection and Assessment System (PIDAS) Steam Line: Cathodic protection was installed at the PIDAS steam line crossing to reduce corrosion on the existing underground portion of the North Steam Line. The project involved excavation of pits at each end of the PIDAS steam line crossing, each approximately 3.65 m square and up to 2.4 m deep. In addition, eight 2.4 m deep holes were augured for the installation of galvanic anodes. After placement of the cathodic protection system was completed, the pits and holes were backfilled.

Evaluation of the radionuclide air emissions from this project used soil contamination information obtained from soil analyses in the PIDAS area (the radionuclides in the excavated soil were well below the RFCA Tier II action levels). Emission factors from Appendix D to 40 CFR 61 and an EPA reference document (EPA, 1995) were used in the emission calculations. While water spray was used to control dust, this factor was not included in the emission calculations. The maximum annual off-Site EDE was estimated to be 1.2×10^{-8} mrem (1.2×10^{-10} mSv).

Installation of Underground Piping from the PIDAS Steam Pits to the

Sanitary Sewer: The scope of this project involved the installation of underground hard piping between two steam pits and the sanitary sewer system. The project was necessary to provide underground piping and flow metering capability for the PIDAS steam pit sump pumps. The lines will carry storm water and melt water that collects in the underground steam line vaults to the sanitary sewer system. The water will subsequently flow to the wastewater treatment plant.

Two trenches, each approximately 0.46 m deep and 48.7 m long, were dug from the north and south steam pits to sewer manholes. Drain line piping was placed in the trenches and the trenches were backfilled.

Soil sampling was conducted to support this project. The EDE estimation used emission factors from 40 CFR 61, Appendix D, and an EPA reference document (EPA, 1995), and was based on the volume of soil excavated and isotopic analysis of the soil samples. While water spray was used to control dust, this factor was not included in the emission calculations. The maximum annual off-Site EDE from the pipeline installation was estimated to be 1.7×10^{-5} mrem (1.7×10^{-7} mSv).

Solar Pond Debris Removal and Decontamination: A project to decontaminate heavy equipment and debris was completed in 1998. The equipment and debris had been used to clean out the Solar Ponds and consisted of two front-end loaders, one forklift, two pontoon boats, one bulldozer, one portable cement mixer, steel pipe, and tires. The debris was decontaminated at the 966 Wash Pad (decontamination pad) northeast of the Solar Ponds using high-pressure water spray.

The maximum contamination level for the equipment was 20 dpm (alpha) per 100 cm², and was assumed to be Am-241 to maximize dose estimation. Radionuclide air emissions were estimated assuming the total surface area of the equipment was contaminated at this level and assuming all radioactive contaminants were emitted. This project did not employ any radionuclide emission controls. The maximum annual off-Site EDE from the decontamination project was estimated to be 3.1×10^{-5} mrem (3.1×10^{-7} mSv).

Mound Site Plume Treatment System: Between April 1954 and September 1958, the Mound Site, Individual Hazardous Substance Site (IHSS) 113, was used as a disposal

site for approximately 1,405 drums containing depleted uranium, beryllium, hydraulic oil, carbon tetrachloride, perchloroethylene, and low levels of plutonium. Prior to the removal of the drums in 1970, some of the drums leaked and contaminated approximately 300 to 750 m³ of soil, primarily with volatile organic compounds (VOCs). The contaminated soil was excavated in 1997 from the Mound Site.

A downgradient capture and treatment system, consisting of a collection trench 82.3 m in length, 0.9 m wide, and 4.9 m deep, and a transport pipe 67 m in length, 0.9 m wide, and 4.9 m deep, was constructed in 1998 to collect and treat contaminated groundwater originating from the Mound Site (Mound Site Plume). Excavation of the two trenches was performed with a backhoe, and backfilling was performed with a front-end loader. Approximately 553 m³ of soil was excavated and backfilled.

Dose calculations from excavation and backfilling activities were based on the most conservative assumption that all particulate emissions would contain the maximum concentrations of radionuclides, as listed in the *Mound Site Plume Field Data Summary* (Rocky Mountain Remediation Services, L.L.C. [RMRS], 1997a). Emission factors from Appendix D to 40 CFR 61 and an EPA reference document (EPA, 1995) were used in the emission calculations. While water spray was used to control dust, this factor was not included in the emission calculations. The maximum annual off-Site EDE from these activities was estimated to be 2.9×10^{-4} mrem (2.9×10^{-6} mSv). The EDE dose was based on the volume of soil excavated and backfilled.

Site Characterization at the 903 Pad: From 1958 to 1967, the 903 Pad was used for storing drums containing plutonium- and uranium-contaminated VOCs. Leaking drums resulted in the contamination of the 903 Pad (IHSS 112). Several remedial actions took place in the 1960s and 1970s to remove hot spots and cap and grade the area. Wind and rain during the remedial actions dispersed some of the contamination to the lip area (IHSS 155), and americium zone. Previous investigations have revealed radiological contamination in the surface soils exceeding RFCA Tier I action levels. The 1998 project used intrusive and non-intrusive field activities for the purpose of identifying and delineating the spatial and vertical extent of radiologically contaminated surface and subsurface soils.

Field activities consisted of surface and subsurface soil sampling, the latter using a geoprobe drilling technology. At least 20 composite grab surface and 9 asphalt samples were collected at the 903 Pad. Approximately 75 soil borings were drilled to 1.5 m in depth, and 20 soil borings were drilled to 8.5 m.

The maximum annual off-Site EDE from this project was estimated to be 3.0×10^{-4} mrem (3.0×10^{-6} mSv). No radionuclide emission controls were associated with this project. Emission estimates were based on the amount of soil disturbed and the maximum radionuclide contamination levels obtained from the soil samples. Emission factors from

Appendix D to 40 CFR 61 and an EPA reference document (EPA, 1995) were used in the emission calculations.

Trench 1 Source Removal: Based on historical information, approximately 125 drums containing an estimated 20,000 kg of depleted uranium metal chips (lathe and machine turnings) were thought to have been buried in T-1, IHSS 108, between 1954 and 1962. The depleted uranium chips were packed in a water-soluble lathe coolant. The trench was also expected to contain trash and debris such as pallets, paper, and empty or crushed drums. The objective of this project was to remove the potentially pyrophoric uranium from the trench and stabilize it, and to remove and treat any associated contaminated debris, soils, or other material.

The project, which was undertaken during the summer of 1998, actually excavated 171 drums of depleted uranium chips and other materials and approximately 1,338 m³ of debris and associated soils. A temporary weather shelter was placed over the trench to protect the site and workers from the elements, and to enclose a soil stockpile. The shelter was not operated as a sealed structure. As materials were removed from the trench, they were screened for radionuclide contaminants and segregated accordingly for treatment and disposal. Any depleted uranium chips and associated contaminated soils that were above the RFCA Tier I action levels were transferred to the sampling and inerting pad (SIP). At the SIP these materials were visually inspected, sampled, rendered inert with mineral oil or dry soil, and packaged for future stabilization and final disposition.

Because complete characterization of the radionuclide contaminant levels present in T-1 was not possible prior to excavation, the maximum potential radionuclide emissions were estimated based on several conservative assumptions regarding the physical state of the depleted uranium, its exposure and dispersion potential, and the overall radionuclide contaminant levels expected in the trench. The depleted uranium chips and turnings were assumed to be in a dispersible, particulate form. The fractions of decay progeny generated from the depleted uranium isotopes over an average of 39 years were also included in the calculations. It was assumed that T-1 also contained, in addition to the depleted uranium drums, a maximum of 40 drums of oil/water mixtures contaminated with plutonium and uranium. The soils not directly associated with the depleted uranium were assumed to be uniformly contaminated at RFCA Tier II threshold levels. The maximum annual off-Site EDE from this project was estimated to be 9.7×10^{-1} mrem (9.7×10^{-3} mSv). It was also assumed the T-1 project did not employ any radionuclide emission controls, although dust control inside the tent and the weather shelter itself minimized emissions.

Because the T-1 source removal project fell under CERCLA, neither a construction permit nor construction/modification approval were required, even though the estimated controlled EDE from the project exceeded 0.1 mrem (0.001 mSv). (Note that in contrast to these pre-project estimates, ambient monitoring during the T-1 source removal indicated no measurable increases in radionuclide concentrations at sampler locations

outside the weather structure.) However, the project was required to satisfy all substantive applicable or relevant and appropriate federal and state requirements that would otherwise have been included in such permit or approval. These requirements were documented in the Proposed Action Memorandum (PAM) for the project, which was initially distributed in July 1997 (RMRS, 1997b). In addition, an Air Pollutant Emission Notice (APEN) for the project was submitted to CDPHE prior to the start of excavation. The PAM and APEN provided notification of project startup.

Initially, radionuclide emissions following excavation of drums and debris were estimated based on backfilling the trench using the original soil excavated from T-1. The project emissions were recalculated when it was decided to include stored soil samples from various areas of the Site, including soils from borehole drilling on the 903 Pad, in the backfill. Emission factors from Appendix D to 40 CFR 61 and an EPA reference document (EPA, 1995) were used in the emission calculations. The maximum annual off-Site EDE from the backfill activity was calculated to be 1.5×10^{-6} mrem (1.5×10^{-8} mSv). This represented a negligible increase above the total dose originally estimated for the T-1 remediation project.

3.0 AIR EMISSIONS DATA

This section discusses and quantifies radionuclide emissions from the Site for calendar year 1998. The stacks, vents, and other points where radioactive materials were released to the atmosphere are described, and the effluent controls employed by the Site to minimize emissions are discussed.

3.1 Emission Determination Process

The emission data presented in this section represent an estimate of total Site radionuclide air emissions in calendar year 1998. The radionuclide emissions presented in this section were used in the dispersion modeling analysis that was prepared for comparison with the alternate compliance demonstration method sampling results (described in Section 4.1 of this report).

In most cases, air effluent exiting buildings through stacks or vents was continuously sampled and radionuclide emissions measured. Where such data were available, the measured emissions were used in the modeling analysis. In other cases, emissions from activities that generated airborne radionuclides were not measured. For these activities, emissions were estimated based on project- or process-specific information, combined with emission factors from various sources.

As described in Section 2.2.2, expected radionuclide emissions must be estimated for proposed new or modified sources of radionuclide air emissions to determine compliance requirements and to evaluate the need for additional controls. For projects or processes whose emissions were not subsequently measured, this initial emission estimate was used for the modeling analysis, as long as the project or process was conducted consistent with the assumptions on which the initial emission estimate was based. In 1998, only the T-1 source removal project was reevaluated and emissions re-estimated for this modeling analysis.

Where emissions reported in this section were estimated, rather than directly measured, the emission estimates were based on:

- The radionuclide content of materials handled or processed;
- The form of the radioactive material (gas, liquid, solid, or particulate);
- The mechanisms by which radionuclides were released to the atmosphere;
- The time over which the activities that released radionuclides occurred or the time that the radioactive material was exposed to the atmosphere;

- The control measures employed to reduce radionuclide emissions (a maximum of two stages of HEPA filters were credited, even if additional stages were actually employed); and
- Process- or activity-specific emission factors.

Emission factors were derived from several sources. Radionuclide emission factors listed in Appendix D to 40 CFR 61 were used to calculate emissions due to exposure of radioactive material to the atmosphere during processing or handling. Additional emissions resulting from the release of radionuclide-contaminated particles through handling or processing soil and debris were based on emission factors in EPA's *Compilation of Air Pollutant Emission Factors* (EPA, 1995). Where appropriate, emission data from a DOE publication, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE, 1994), were also used. The appropriate emission factors were combined with project- or process-specific information to yield estimated radionuclide emissions.

In addition to the emission estimates calculated for specific projects or processes, an ongoing source of radionuclide emissions from the Site is the resuspension of contaminated surface soils by wind erosion. Emissions from this source were estimated by combining information regarding Sitewide surface soil concentrations of radionuclide contaminants with a Site-specific soil resuspension factor. The development of the Site-specific soil resuspension factor used in emission calculations was discussed in detail in a previous annual report (DOE, 1996).

Historical surface soil radionuclide concentration data from a Site-specific soil sampling database were used to develop a set of radionuclide concentration isopleths spanning the entire Site. New soil samples were added to the database in 1998; therefore, the soil resuspension emissions for 1998 reflect information based on new concentration isopleths.

3.2 Point Sources

Radionuclide emissions released through stacks and vents are termed "point" sources. In 1998, radionuclide point sources at the Site included releases from continuously sampled locations in the industrial area, as well as several sources where emissions were calculated rather than measured.

Point source emissions for calendar year 1998 and the control technology used on each point source are described in this section.

3.2.1 Measured Point Source Emissions

During 1998, radionuclide emissions were collected and measured at two types of point

sources: significant release points and insignificant release points. Significant release points are those that have the potential to discharge radionuclides into the air in quantities that would result in an annual EDE to the public greater than 1% of the 10 mrem standard, based on uncontrolled emissions (without considering HEPA filtration). Insignificant release points are those that have the potential to discharge radionuclides in lesser quantities. Significant release points must be continuously monitored or sampled, while insignificant release points require periodic confirmatory measurements to verify low emissions (40 CFR 61.93).

Point source emissions are measured at the Site with a sampling system that continuously draws a portion of the duct or vent airstream through a filter. Radioactive particles collect on the filters, which were exchanged weekly at the significant sampling locations and monthly at the insignificant locations in 1998. Following collection, the filters were screened for long-lived alpha and beta radiation to check for elevated radionuclide emissions.

Following alpha/beta screening, the samples were composited by location and analyzed for plutonium, uranium, and americium isotopes. All radionuclides that could contribute greater than 10% of the potential EDE for a release point were measured. Monthly composites were analyzed for each significant location. An annual composite was analyzed for each insignificant location.

Tritium, which is emitted as a gas, is also sampled continuously at some locations. Tritium is collected by bubbling the duct or vent airstream through purified water. Tritium samples were analyzed as they were collected, three times a week.

Due to the complexity of the building ventilation systems at the Site, the number of sampling points used is not a one-to-one match with the number of release or emission points. In some cases, effluent streams that are sampled separately are combined prior to release to the atmosphere. At other locations, a single probe may monitor an effluent stream that is released through multiple stacks or vents.

In 1998, particulate samples were collected at 48 routine sampling locations representing 47 release points. Of the 48 routine sampling locations, 19 were identified as significant point source locations and 29 were insignificant locations. Building 779, Plenum 404, was not open to the atmosphere until November 1998. Due to changes in activities or material handled, Building 991, vents 991-985 and 991-MAI, and Building 778, vent 778-LDY, no longer emit radionuclides and were not measured during 1998.

Measured 1998 emissions of plutonium, uranium, and americium are shown in Table 3-1. Unlike prior years, only positive results are included in the 1998 emission values shown in Table 3-1. Four emission points were also sampled for tritium, as indicated in Table 3-1.

**Table 3-1. Measured Point Source Radionuclide Emissions for
Calendar Year 1998**

Building/ Location ^a	Isotope Emissions (Ci/yr) ^{b,c,d}					
	Pu-239/240	Am-241	U-233/234	U-235	U-238	H-3
Significant Release Points						
371-N01	5.29E-09	1.11E-09	6.71E-09	1.86E-09	4.62E-09	--
371-N02	1.33E-08	2.86E-09	2.78E-09	2.23E-09	3.29E-09	--
371-SSS	7.45E-10	1.26E-10	7.83E-10	6.71E-10	1.07E-09	--
374-MAI ^e	3.20E-09	2.03E-09	5.57E-09	1.94E-09	3.71E-09	--
559-561 ^e	5.04E-09	1.27E-09	1.22E-08	4.95E-09	1.41E-08	--
707-101 ^e	1.11E-10	7.45E-11	2.20E-10	9.88E-11	2.30E-10	--
707-102 ^e	2.48E-10	2.69E-10	8.71E-10	2.34E-10	6.21E-10	--
707-105 ^e	7.41E-10	2.33E-10	3.31E-09	1.35E-09	1.65E-09	--
707-106 ^e	5.00E-10	1.54E-10	1.15E-09	2.76E-10	8.12E-10	--
707-107 ^e	1.28E-09	2.21E-09	9.62E-09	1.49E-09	1.20E-08	--
707-108 ^e	1.09E-09	6.61E-10	3.83E-09	1.07E-09	3.45E-09	--
771-MAI ^e	1.55E-08	1.08E-08	4.85E-08	2.45E-08	2.52E-08	--
774-202 ^e	2.71E-10	4.59E-10	9.98E-10	9.84E-10	6.23E-10	--
776-201 ^e	4.32E-11	5.61E-11	2.08E-10	6.14E-11	2.32E-10	--
776-204 ^e	7.07E-10	2.16E-09	9.35E-09	1.17E-09	7.37E-09	--
776-205 ^{e,f}	3.21E-09	2.81E-09	5.83E-09	1.81E-09	6.42E-09	--
776-205T	--	--	--	--	--	2.99E-06
776-206T	--	--	--	--	--	1.81E-05
779-729	9.91E-10	5.25E-10	1.65E-09	8.32E-10	1.03E-09	--
779-782	7.26E-09	2.64E-09	5.09E-09	2.84E-09	5.66E-09	--
Insignificant Release Points						
374-SPD	2.23E-09	3.58E-09	2.85E-10	2.80E-11	5.65E-10	--
444-DO5	1.90E-11	--	--	5.06E-11	--	--
444-MAI	6.15E-09	--	--	1.04E-09	--	--
447-MAI	3.35E-10	--	--	--	--	--
707-R21A/B	4.69E-10	--	6.51E-10	--	--	--
707-R22A/B	2.62E-09	8.88E-10	1.75E-09	1.69E-11	--	--
707-R23A/B	3.34E-10	--	--	--	--	--
707-R24A/B	9.39E-10	2.03E-10	--	--	--	--
707-R25A/B	2.03E-10	--	--	--	--	--
707-R26A/B	1.23E-10	--	--	4.61E-10	--	--
707-R27A/B	1.92E-09	--	--	--	--	--
707-R45A/B	8.46E-11	--	--	--	--	--
707-R46A/B	--	--	--	3.59E-10	--	--
771-CMA	4.88E-09	5.36E-10	--	--	--	--
771-CRM	7.62E-09	1.77E-09	1.30E-10	8.08E-11	--	--
776-202	9.03E-10	--	--	--	--	--
776-250	3.99E-08	--	5.42E-09	--	--	8.34E-06
776-251	8.40E-10	--	--	4.46E-11	--	7.54E-06
776-252	6.83E-08	8.14E-09	--	--	--	--
779-404 ^g	3.41E-10	1.23E-10	1.57E-09	7.00E-10	6.32E-10	--

**Table 3-1. Measured Point Source Radionuclide Emissions for
Calendar Year 1998 (Continued)**

Building/ Location ^a	Isotope Emissions (Ci/yr) ^{b,c,d}					
	Pu-239/240	Am-241	U-233/234	U-235	U-238	H-3
Insignificant Release Points (continued)						
865-EEE	2.10E-09	--	--	--	--	--
865-WWW	--	--	--	--	--	--
881-MA1	1.16E-08	--	1.90E-09	2.51E-10	--	--
881-MA2	3.16E-09	--	--	--	--	--
881-MA3	1.87E-09	--	--	--	--	--
881-MA4	1.79E-09	--	1.04E-08	3.46E-10	3.46E-10	--
883-AAA	1.34E-10	--	--	1.27E-10	1.65E-09	--
883-BBB	1.31E-09	--	--	8.71E-11	--	--
883-CCC	1.12E-09	--	--	--	--	--
886-875	5.26E-10	1.08E-09	1.85E-09	7.00E-10	1.79E-09	--

^a The first number in this column designates the building cluster, the second set of characters designates the specific duct(s) or vent(s). The location of each release point is shown in Figure 4-3 of this report.

^b Values were corrected for filter blanks.

^c All measured point sources were controlled by HEPA filters with a tested control efficiency of at least 99.97%.

^d All isotopes that could contribute greater than 10% of the potential EDE for a release point were measured. Isotopes not analyzed are shown as "--".

^e Shrouded probe data were used.

^f Release points 776-205, -206, and -207 were combined through a mixing plenum and were sampled with one shrouded probe identified as 776-205.

^g Release point 779-404 became active in November 1998.

Notes:

Ci/yr = Curies per year, 1 Ci = 3.7×10^{10} Becquerel (Bq)

Pu = Plutonium

Am = Americium

EDE = Effective dose equivalent

HEPA = High efficiency particulate air

H-3 = Tritium

U = Uranium

E# = $\times 10^{\#}$

-- = Not analyzed

In calendar year 1997, 18 particulate sampling locations were upgraded to single-point shrouded probe sampling systems as required by a 1994 agreement between DOE and EPA (Brockman, 1995). Data from these new samplers were used for the 1998 data set as indicated in Table 3-1. Single-point shrouded probe sampling systems were also installed at locations 371-N01, 371-N02, and 371-SSS, and were operated concurrently with the existing multi-point sampling systems. Because the airflow patterns within the ducts in Building 371 did not produce uniform mixing, the data from the shrouded probe samplers were not included in Table 3-1; instead the multi-point sampling system data were used for this report.

In addition to routine measurements, special air sampling was performed in three locations within Building 779. The special samplers measured radioactivity in room air that was subsequently exhausted through two stages of HEPA filters. Emissions of plutonium, uranium, and americium were calculated based on this information, rather than directly measured, and are therefore presented in Section 3.2.2 (below).

Appendix B shows 1998 measured point source emissions data normally contained in DOE's Effluent Information System (EIS)/Off-Site Discharge Information System (ODIS). DOE did not publish an EIS/ODIS report for 1998.

3.2.2 Calculated Point Source Emissions

During 1998, several point sources operated at the Site that did not trigger continuous sampling requirements because they had low emission potential or were of short duration. These sources included Building 123 decommissioning activities, emissions from process waste tank vents in Building 776, and Thermo NUtech Modular Analytical Laboratory activities, which were described in Section 2.2.2. Low-level tritium emissions from Building 790 were also calculated for 1998. Finally, radionuclide emissions from glovebox removal in Building 779, while measured, required additional calculations to estimate the actual emissions. Calendar year 1998 emissions from these point sources and the methods used to minimize emissions are described below.

Emissions were calculated for these insignificant release points as described in Section 3.1. Table 3-2 shows calculated point source emission estimates for calendar year 1998.

Building 123 Decommissioning: In 1998, Building 123, a former laboratory building, was decommissioned and demolished. In the course of the demolition, elevated levels of radionuclide contamination were discovered in a cabinet under a laboratory hood and on a concrete slab in Room 105. The contaminated areas were remediated. An air mover with a single-stage HEPA filter was used to vent the room.

**Table 3-2. Calculated Point Source Radionuclide Emissions for
Calendar Year 1998**

Activity or Building	Isotope Emissions (Ci/yr) ^a					
	Pu-239/ 240	Am-241	U-233/234	U-235	U-238	H-3
Building 123 Decommissioning ^b	7.9E-08	9.2E-08	9.6E-07	9.3E-08	1.0 E-06	--
Glovebox Removal in Building 779, Plenum 405 ^b	2.7E-10	4.5E-11	1.6E-12	3.3E-13	3.1E-12	--
Thermo NUtech Modular Analytical Laboratory ^c	--	--	--	--	--	1.5E-07
Building 776 Process Waste Tanks ^b	3.2E-08	4.0E-06	--	--	--	--
Building 790 ^d	--	--	--	--	--	1.5E-06

^a Emissions of all isotopes that could contribute greater than 10% of the potential EDE for a release point were estimated. Isotopes for which emissions were not estimated are shown as "--". The locations of the release points listed are shown in Figure 4-3 of this report.

^b HEPA filtration used with a control efficiency of at least 99.97%.

^c Assumed uncontrolled.

^d Uncontrolled for tritium.

Notes

Ci/yr = Curies per year, 1 Ci = 3.7×10^{10} Becquerel (Bq)
 Pu = Plutonium
 Am = Americium
 EDE = Effective dose equivalent
 HEPA = High efficiency particulate air
 U = Uranium
 H-3 = Tritium
 -- = Not estimated/negligible
 E# = $\times 10^{\#}$

Glovebox Removal in Building 779: The 1998 activities in Building 779 involved the removal and size reduction of gloveboxes, B-boxes, and hoods in areas venting to Plenums 404 and 405. Effluent streams were exhausted through two stages of HEPA filters. Plenum 404 was opened to the atmosphere in November 1998 and air emissions from this duct were sampled downstream of the HEPA filtration. The measured emissions are included in Table 3-1. Activities that had the potential to emit radionuclides through Plenum 405 were measured by air sampling heads located in the rooms where the size-reduction enclosures were located. Samples from these room-air sampling heads were collected weekly, composited, and analyzed monthly. To estimate the radionuclide emissions, the removal efficiency of the two stages of HEPA filters and the maximum measured room air concentrations were used, assuming that 60% of the total plenum system flow exhausted to the atmosphere and that 40% was recirculated into the building. The calculated emissions of plutonium, uranium, and americium for 1998 from Plenum 405 are shown in Table 3-2.

Thermo NUtech Modular Analytical Laboratory: In 1997, five laboratory operations were transferred from Buildings 881 and 123 to the Thermo NUtech Modular Analytical Laboratory. All were scheduled to operate in 1998. Radionuclide emissions were calculated based on an estimate of the total annual radioactivity encountered during laboratory operations and assuming no radionuclide emission controls were employed. In actuality, the waste storage area vents through a HEPA filter, while other emission points do not employ radionuclide emission controls.

Building 776 Process Waste Tanks: Building 776 has process waste tanks in Room 127 that vent (passive vent) to the atmosphere through one HEPA filter. Emissions for 1998 were calculated based on the conservative assumption that all of the waste material was contaminated at the highest recorded plutonium concentration based on historical sampling data.

Building 790: As a result of instrumentation calibration in Building 790 (Health Physics Instrumentation Facility), low-level tritium emissions were calculated for 1998. The tritium emissions were based on monthly reports that documented the total number and the tritium activities of the calibration solutions used. The total tritium contained in 1998 calibration solutions was assumed to have been emitted. No radionuclide emission controls were employed.

3.2.3 Control Technology for Point Sources

HEPA filters are used to control radioactive particulate emissions from air effluent systems. All of the point source locations listed in Table 3-1 used HEPA filtration in 1998. Air effluent from plutonium processing areas was cleaned by a minimum of four stages of HEPA filters. Air effluent from areas that processed plutonium-contaminated waste was typically cleaned by four stages of HEPA filters. Air effluent from uranium processing areas was generally cleaned by a minimum of two stages of HEPA filters. HEPA filters are bench tested prior to installation in the buildings to ensure that they

would meet a minimum filter efficiency of 99.97 percent (Novick, et al., 1985). Filter assemblies are tested again for leaks following installation.

Emissions from the Building 123 decommissioning and Building 776 process waste tanks closure activities were controlled using at least single-stage HEPA filtration. Glovebox removal in Building 779 was controlled by two stages of HEPA filters. Thermo NUtech activities were generally uncontrolled, except for the waste storage area, which vents through a HEPA filter. The tritium emissions shown in Tables 3-1 and 3-2 were uncontrolled (HEPA filters do not control tritium, which is released as a gas).

3.3 Nonpoint Sources

Radionuclide emissions that are not released through specific stacks or vents are termed "nonpoint" (or diffuse) sources. In calendar year 1998, nonpoint sources of radionuclide emissions at the Site included resuspension of contaminated soils by wind erosion and by mechanical disturbance due to excavation, handling, and vehicle traffic. Mechanical disturbance of contaminated soils was associated with:

- The T-1 source removal project;
- The project to construct a new loading dock on the west side of Building 371;
- The project to install cathodic protection for the North PIDAS Steam Line;
- The excavation and installation of underground piping from the PIDAS steam pits to the sanitary sewer system;
- The Mound Site Plume project; and
- The 903 Pad site characterization project.

Finally, 1998 nonpoint sources also included the Building 788 clarifier tank draining project, the project to remove and decontaminate Solar Pond equipment and debris, and the ongoing drum crushing operation in the Protected Area.

Calendar year 1998 emissions from nonpoint sources and the methods used to minimize emissions are described below. The projects and operations that generated nonpoint air emissions of radionuclides in 1998 are described in greater detail in Sections 2.2.1 and 2.2.2 of this report. Table 3-3 summarizes emissions from nonpoint sources for calendar year 1998. The emissions shown in Table 3-3 include the uranium isotopes typical of the depleted and enriched uranium that have been used at the Site, as well as other isotopes that are present in Site soils. Pu-239/240 constitutes more than 97% of the alpha activity in plutonium used at the Site. Consequently, emissions for selected plutonium isotopes (Pu-238, -241, and -242) were not included in the 1998 emission estimates because each has the potential to contribute much less than 10% of the total EDE.

3.3.1 Nonpoint Source Descriptions

Resuspension of Contaminated Soils by Wind Erosion: As described in Section 3.1, an ongoing source of radionuclide emissions from the Site is the resuspension of contaminated soil. Calendar year 1998 emissions from wind erosion of contaminated soil are summarized in Table 3-3 and are labeled as isopleths. Each isopleth encompasses an area of equal soil resuspension emission potential for a given isotope.

T-1 Source Removal Project: In 1998, the T-1 site was remediated. Approximately 171 drums containing an estimated 20,000 kg of depleted uranium metal chips and a limited amount of other material were buried in the trench between 1954 and 1962. The project involved the excavation of approximately 191 m³ of soil and drums of depleted uranium chips from the west end of the trench, and the excavation of approximately 1,146 m³ of debris and associated soils from the remaining portions of the trench.

Radionuclide air emissions were generated from excavation operations and from transferring material between the excavator, packing containers, and soil stockpile. Also, passive radionuclide emissions were generated from exposure of the depleted uranium and other potential radionuclide contaminants to the atmosphere. A temporary structure (tent) constructed over the T-1 site to protect the site and workers from the elements also served to control fugitive emissions by allowing larger particles to settle out, and by protecting the site from high winds. Water spray and dust suppressants were also used both inside and outside the temporary structure to control fugitive dust emissions during excavation and material handling activities.

An enhanced, project-specific ambient air monitoring program was implemented during excavation, segregation, sampling, and inerting of depleted uranium chips and associated soils and wastes at T-1. The project-specific ambient air monitoring for T-1 consisted of enhanced routine monitoring in the immediate vicinity of the T-1 project using the existing RAAMP network at the Site. To characterize the radionuclide emissions generated by activities conducted inside the temporary structure, three high-volume particulate air samplers were located near the activities with the greatest potential to release radionuclides into the atmosphere. These samplers operated continuously during the trench excavation and material handling activities. The filters from the three air samplers were collected and exchanged approximately two times each week and screened for gross alpha/beta contamination. The filters were composited for isotopic analysis. Data from these three samplers were combined with the ventilation rate from fans in the roof of the tent to estimate emissions from the project.

Building 371 Loading Dock: A new loading dock was built on the west side of Building 371. Soil sample results indicated that radionuclide levels were not above background levels. Radionuclide emissions were calculated using the amount of soil excavated and assuming contamination at the maximum levels detected in soil samples from the area. No emission controls were employed for this project.

**Table 3-3. Nonpoint Source Radionuclide Emissions
for Calendar Year 1998**

Isopleth or Project ^a	Isotope Emissions (Ci/yr) ^b				
	Pu-239/240	Am-241	U-233/234	U-235	U-238
Isopleth 1	4.7E-07	7.6E-08	2.2E-08	5.3E-09	5.5E-10
Isopleth 2	1.6E-09	4.5E-09	--	7.9E-11	4.0E-09
Isopleth 3	3.1E-07	9.5E-07	--	1.7E-09	1.4E-07
Isopleth 4	2.4E-06	3.9E-07	--	7.1E-10	1.1E-09
Isopleth 5	--	2.1E-07	--	1.5E-09	--
Isopleth 6	1.0E-07	2.2E-07	--	7.2E-09	--
Isopleth 7	4.5E-09	2.6E-07	--	--	--
Isopleth 8	1.7E-06	2.1E-07	--	--	--
Isopleth 9	2.7E-06	4.7E-07	--	--	--
Isopleth 10	9.2E-07	6.5E-07	--	--	--
Isopleth 11	1.4E-06	1.1E-06	--	--	--
Isopleth 12	3.8E-06	--	--	--	--
Isopleth 13	5.9E-06	--	--	--	--
Isopleth 14	1.2E-10	--	--	--	--
Isopleth 15	2.9E-09	--	--	--	--
Isopleth 16	1.1E-05	--	--	--	--
Isopleth 17	5.8E-09	--	--	--	--
Isopleth 18	4.8E-07	--	--	--	--
Isopleth 19	5.3E-10	--	--	--	--
Isopleth 20	8.2E-10	--	--	--	--
T-1 Source Removal ^c	3.0E-08	8.6E-09	3.0E-07	2.9E-07	1.2E-06
Building 371 Loading Dock ^d	1.0E-06	1.1E-06	1.7E-05	1.7E-05	1.6E-05
Cathodic Protection/North PIDAS ^{c,d}	7.7E-12	6.2E-11	2.8E-10	1.8E-10	2.8E-10
Piping Installation PIDAS Steam Pits ^{c,d}	1.3E-08	1.0E-07	4.7E-07	3.4E-08	4.8E-07
Mound Site Plume Treatment ^{c,d}	7.6E-07	7.8E-07	9.0E-06	6.6E-07	7.7E-06
Site Characterization 903 Pad ^d	4.2E-06	1.3E-06	--	--	2.0E-09
Building 788 Clarifier Tank ^d	--	9.6E-04	--	--	--
Solar Pond Removal/Decontamination ^d	--	5.6E-07	--	--	--
Drum Crushing ^d	4.6E-08	--	--	--	--

^a Isopleths are specific to each isotope and indicate zones of equal radionuclide emission potential for contaminated surface soils.

^b Emissions of all isotopes that could contribute greater than 10% of the potential EDE for a release point were estimated. Isotopes for which emissions were not estimated are shown as "--". The locations of the nonpoint release emission sources are shown in Figures 4-3 through 4-9 of this report.

^c Water spray/dust suppression used with a control efficiency of 50 percent.

^d Assumed to be uncontrolled in estimating emissions.

Notes

Ci/yr = Curies per year, 1 Ci = 3.7×10^{10} Becquerel (Bq)
 Pu = Plutonium
 Am = Americium
 EDE = Effective dose equivalent
 PIDAS = Perimeter Intrusion Detection and Assessment System

T-1 = Trench 1
 U = Uranium
 -- = Not estimated
 E# = $\times 10^{\#}$

Cathodic Protection Installation for the North PIDAS Steam Line: The installation of cathodic protection for the North PIDAS Steam Line required excavation and backfill of two areas 3.65 meters square and up to 2.4 m deep, plus eight augured holes approximately 2.4 m deep. Emissions were estimated using the total volume of soil disturbed and contamination levels from soil sampling data. While water spray was used to control dust, this factor was not included in the emission calculations.

Installation of Underground Piping from the PIDAS Steam Pits to the Sanitary Sewer: Two drain lines, from the PIDAS steam pits to the sanitary sewer system, were excavated and installed in 1998. Emissions were estimated using the total volume of soil disturbed and contamination levels from the soil sampling data. While water spray was used to control dust, this factor was not included in the emission calculations.

Mound Site Plume Treatment System: A downgradient capture system and treatment cell to collect and treat contaminated groundwater moving from the Mound Site toward South Walnut Creek was constructed in 1998. The project consisted of excavation and backfill of a collection trench and a transport line. Soil radionuclide concentrations were assumed to be the maximum concentrations obtained from the Mound Site Plume Field Data Summary (RMRS, 1997a). The soil was sprayed with water during excavation and backfilling to control dust and any associated radionuclide emissions.

Site Characterization at the 903 Pad: In 1998, surface and subsurface soil sampling was performed at the 903 Pad (IHSS 112), lip area (IHSS 155), and americium zone. Approximately 100 boreholes were excavated to varying depths using a geoprobe drilling technology to sample the soils for VOC and radionuclide concentrations. Radionuclide emissions were estimated using the maximum measured soil activity concentrations, average soil density, and estimated soil volume excavated from the boreholes. No emission controls were employed for this project.

Building 788 Clarifier Tank: In 1998, the Solar Ponds clarifier tank located next to Building 788 was emptied of sludge, which was pumped into smaller tanks and transported to the 750 Pad. Water sprays were used to loosen the sludge to enhance pumping. Radionuclide air emissions were estimated based on gross alpha measurements from representative sludge laboratory data, and on a conservative emission factor for high-pressure water spray, assuming no emission controls.

Solar Pond Debris Removal and Decontamination: In 1998, seven pieces of heavy equipment and several miscellaneous items were removed from the Solar Ponds area and decontaminated at the 966 Wash Pad (decontamination pad). Radionuclide air emissions were estimated using the highest contaminant readings for the total surface area of the equipment being decontaminated, and assuming all radioactive contaminants were emitted. The project did not employ radionuclide emission controls.

Drum Crushing: To reduce waste volume, a drum crushing operation was adjacent to Building 984 within the Protected Area. Emission estimates as a drum crushing operation would process up to 500 nonhazardous drums in drums may have been contaminated with low levels of radionuclides. The operation did not employ emission controls.

3.3.2 Control Technology for Nonpoint Sources

Particulate emissions from significant earth-moving activities at the Site, such as those involved in the remediation of T-1 and several of the other projects listed in Table 3-1, required excavation, were controlled by water spray or other dust suppression measures with an estimated control efficiency of 50 percent. Fugitive dust control plans specified the control measures to be used to minimize emissions of contaminants. Specific control measures were developed for each project with the potential to generate significant particulate emissions from soil or debris handling. In addition, the T-1 source removal trench was covered by a weather shelter that protected the trench site from high winds and allowed particulate (and associated radionuclide) emissions to settle out. Other nonpoint sources discussed above did not employ radionuclide controls.

4.0 COMPLIANCE ASSESSMENT

This section describes the compliance assessment performed for the Site for the 1998 calendar year. Because the Site is transitioning from the historical compliance demonstration method based on emission measurement/calculation, coupled with dispersion modeling, to an alternate sampling-based method, two separate compliance assessments are presented.

4.1 Compliance Demonstration Based on Environmental Measurements

Historically, the Site has demonstrated compliance with the annual 10 mrem public dose standard in 40 CFR 61, Subpart H, through measurement and dispersion modeling of the effluent (measured point) source emissions and emission estimation and dispersion modeling of the nonpoint and calculated point source emissions, to determine the dose to the most impacted off-Site resident. Beginning with calendar year 1998, the Site is transitioning to an alternate compliance demonstration method based on environmental measurements, as described below.

As the Site continues to work toward cleanup and closure, buildings that contain significant quantities of radionuclide materials are being deactivated. In many cases, equipment removal and structural demolition are being carried out, with the existing ventilation systems disrupted or dismantled at some point in the process. Deactivated buildings may contain enough potentially dispersible contamination to exceed the annual monitoring threshold of 0.1 mrem (0.001 mSv) based on potential uncontrolled emissions. However, without functioning ventilation systems, normal effluent emission collection and measurement cannot be performed.

Environmental remediation projects present a similar dilemma. Radionuclide emissions occur from disturbance of contaminated soils and debris, as well as from waste treatment, handling, and packaging activities. As with building deactivation and decommissioning, normal effluent emission collection and measurement are not possible for most such activities.

As buildings are closed, and as the number of environmental remediation projects increases, the number of effluent source locations where emissions are directly collected and measured has decreased and the number of sources at the Site where emissions must be estimated has increased. In such cases where nonpoint sources are primary contributors to dose, as has been the case at the Site since before 1995, an alternative environmental measurement approach is recommended for demonstrating compliance with the public dose standard of 40 CFR 61, Subpart H (EPA, 1991).

In recognition of this fact, DOE submitted a proposal to EPA and CDPHE in July 1997 describing an alternative compliance demonstration approach, as allowed by 40 CFR 61.93(b)(5), based on the existing perimeter RAAMP sampler network (DOE, 1997a). The ambient samplers collect both fine and coarse particulate fractions continuously on filters and removable impactor surfaces that are exchanged and analyzed on a monthly schedule. The samples are analyzed for the plutonium, uranium, and americium isotopes that represent most of the radioactive materials handled at or residing on the Site. These isotopes account for all materials that have the potential to contribute 10% or more of the dose to the public.

CDPHE responded to the DOE proposal in September 1997, approving the proposed approach (Fox, 1997). EPA responded in July 1998, conditionally approving the plan and requesting additional information (Rushin and Clough, 1998).

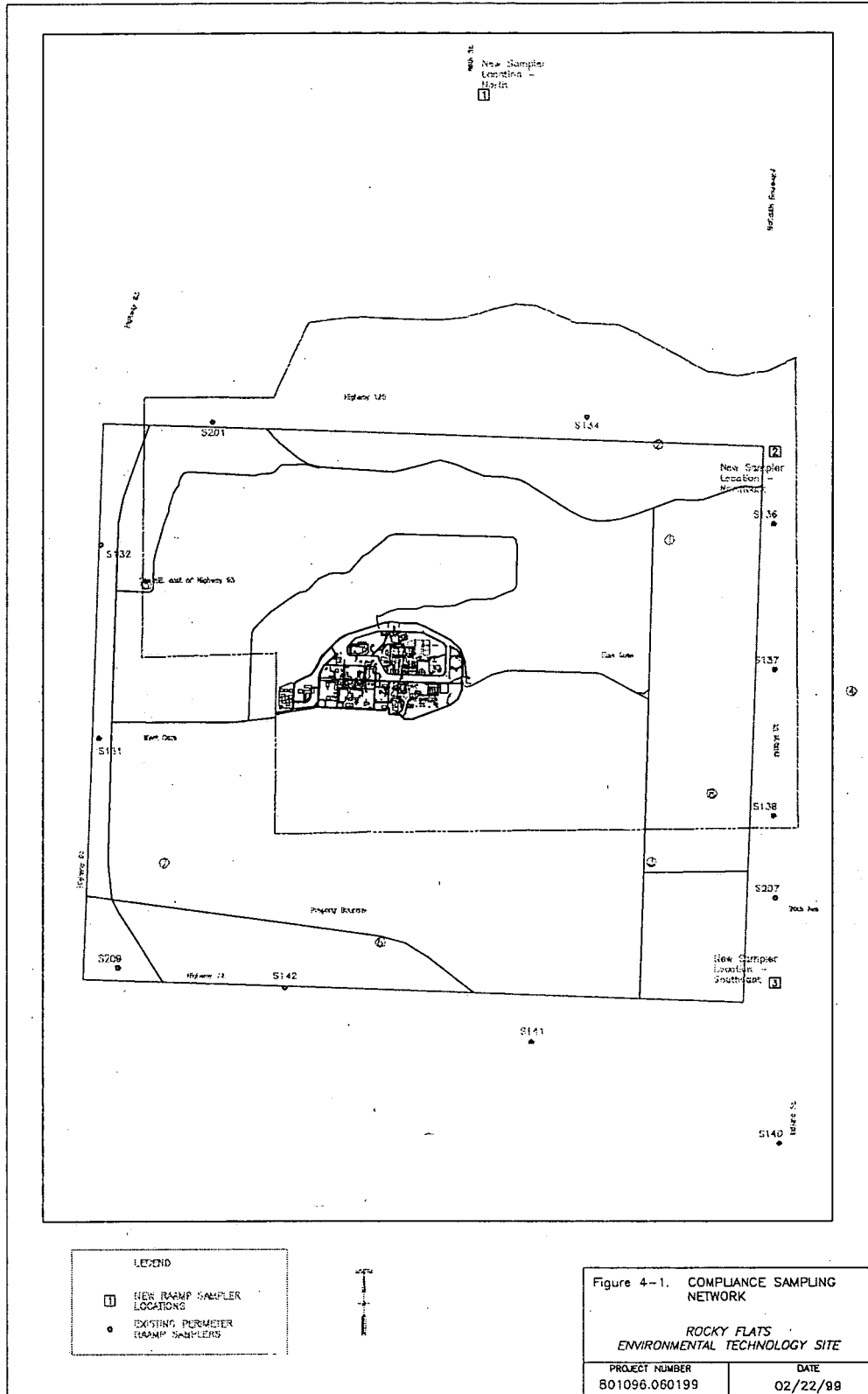
In December 1998, DOE submitted an addendum to the original July 1997 proposal, responding to EPA comments on the original proposed compliance demonstration network (DOE, 1998) and submitting maps and diagrams showing the final configuration of the environmental sampling network that will be used to demonstrate compliance (discussed below).

4.1.1 Description of Compliance Sampling Network

The Site operates an existing network of environmental samplers (the RAAMP network) that consists of 36 high-volume, size-fractionating ambient air samplers located on and around the Site, and in nearby communities. The network was described in detail in DOE's July 1997 alternate compliance demonstration method proposal (DOE, 1997a).

Twelve of the existing RAAMP samplers are located along the Site perimeter. These samplers, which are shown in Figure 4-1, represent the compliance sampling network as it operated during calendar year 1998.

The revised compliance sampling network that is being completed in 1999 will retain 11 of those samplers at their existing locations. One of the existing samplers (S-140), currently located at the intersection of Highway 72 and Indiana Street, will be moved north along Indiana. In addition, two new samplers will be installed to complete the compliance sampling network, one at the northeast corner of the Site fenceline near the intersection of Highway 128 and Indiana Street and the other due north of the center of



the Site, on South 66th Street. The final sampler locations are shown in Figure 4-1. The additional and relocated samplers will be operational by the end of September 1999. Compliance sampling network operations will not change from calendar year 1998 practices. Filters will be exchanged and analyzed monthly for the plutonium, americium, and uranium isotopes of interest.

DOE will review residential and commercial development on or around the Site on a quarterly basis. If new development or privatization projects warrant additional or revised sampler locations, EPA and CDPHE will be notified. Sampler installation will be scheduled so that samplers will be operational when the new residence or business is occupied.

As the Site completes the transition to the alternative compliance demonstration method, effluent collection and measurement will be discontinued for insignificant release points on Site and the ambient network will be used to verify low emissions from these locations, as required by Section 61.93(b)(4). Emissions from significant release points will continue to be measured with the existing effluent sampling systems. The samplers will remain operational until the buildings are actively being decommissioned or until the operations that exceeded the 0.1 mrem trigger have ceased.

4.1.2 Compliance Sampling Network Measurements for 1998

Filters from the compliance sampling network were exchanged monthly during 1998, then analyzed for Pu-239, Am-241, U-233/234, U-235, and U-238. These isotopes accounted for all materials that had the potential to contribute 10% or more of the dose to the public. Annual average isotopic concentrations were calculated at each sampler from the monthly concentration and air volume data. The annual average isotopic concentrations for each of the 12 compliance demonstration samplers that operated in 1998 are shown in Table 4-1.

The fractional sum was calculated for each sampler location by dividing each annual isotopic concentration by that isotope's corresponding compliance level in Table 2 of Appendix E to 40 CFR 61, then summing the fractions. The fractional sums are also shown in Table 4-1.

4.2 Compliance Demonstration Based on Modeling

The Site has agreed to provide a modeling-based compliance assessment during the transition period for comparison with the sampling-based assessment described above. This section discusses the dose assessment performed for calendar year 1998.

**Table 4-1. Annual Isotopic Concentrations at Compliance Sampling
Network Locations for Calendar Year 1998**

Sampler	Annual Isotopic Concentrations					Fractional Sum
	Pu-239 (Ci/m ³)	Am-241 (Ci/m ³)	U-233/234 (Ci/m ³)	U-235 (Ci/m ³)	U-238 (Ci/m ³)	
S-131	1.58 E-18	7.45 E-19	3.21 E-17	1.57 E-18	3.24 E-17	0.0098
S-132	1.69 E-18	5.06 E-19	4.85 E-17	2.04 E-18	4.87 E-17	0.0141
S-134	1.36 E-18	4.76 E-19	2.13 E-17	1.76 E-18	1.87 E-17	0.0064
S-136	1.05 E-18	1.25 E-18	1.92 E-17	1.12 E-18	1.86 E-17	0.0063
S-137	2.31 E-18	1.03 E-18	2.63 E-17	1.08 E-18	2.54 E-17	0.0086
S-138	1.85 E-18	4.84 E-19	2.25 E-17	9.12 E-19	2.06 E-17	0.0070
S-140	1.88 E-18	9.06 E-19	4.78 E-17	2.25 E-18	4.60 E-17	0.0140
S-141	1.67 E-18	3.10 E-19	2.25 E-17	1.05 E-18	2.38 E-17	0.0072
S-142	1.05 E-18	7.20 E-19	2.44 E-17	2.16 E-18	2.07 E-17	0.0072
S-201	1.68 E-18	1.41 E-18	2.68 E-17	1.26 E-18	2.46 E-17	0.0085
S-207	1.08 E-18	6.21 E-19	2.66 E-17	1.65 E-18	2.78 E-17	0.0082
S-209	9.83 E-19	5.31 E-19	2.52 E-17	1.29 E-18	2.21 E-17	0.0072
Compliance Level (Ci/m ³) ^a	2.0 E-15	1.9 E-15	7.1/7.7 E-15	7.1 E-15	8.3 E-15	1

^a Compliance levels are listed for each isotope in Table 2 of Appendix E to 40 CFR 61.

Notes:

Am = Americium
 Ci/m³ = Curies per cubic meter; 1 Ci = 3.7 x 10¹⁰ Becquerel (Bq)
 E# = x 10[#]
 Pu = Plutonium
 U = Uranium

4.2.1 Description of Dose Model

The Site used the dose model CAP88-PC (Version 1.0) for calculating EDE to the public. CAP88 is specified in 40 CFR 61, Subpart H, for modeling air pathway dose from DOE facilities such as Rocky Flats. The model simulates the dispersion of airborne radionuclide emissions from point and nonpoint (termed "area") sources to user-specified receptor locations, then calculates an annual, multipathway EDE for a person living or working at each specified receptor location.

The model accounts for dose received from Site emissions through inhalation and ingestion of radionuclides, as well as through irradiation from radionuclides in air and deposited on the ground surface. To simulate pollutant dispersion and calculate dose, the model requires the following types of input data:

- Distance and direction from emission sources to receptor locations.
- Source release characteristics including stack locations, stack heights, exhaust gas velocities and temperatures, the size of each stack or vent opening for point sources, and the size and location of each area source.
- The amount of each radioactive isotope released from each source.
- Meteorological data including the annual distribution of wind speed, wind direction, and atmospheric stability at the Site, and annual precipitation and temperature information. The model also requires information about the average height of regional temperature inversions (mixing height).
- Agricultural data used in calculating radionuclide ingestion rates including the location, distribution, and utilization of local sources of meat, milk, and vegetables.
- Miscellaneous data regarding the size and solubility of particles emitted.

The input data used in calculating the calendar year 1998 Site dose to the public are discussed in Section 4.2.2.

4.2.2 Summary of Model Input Data

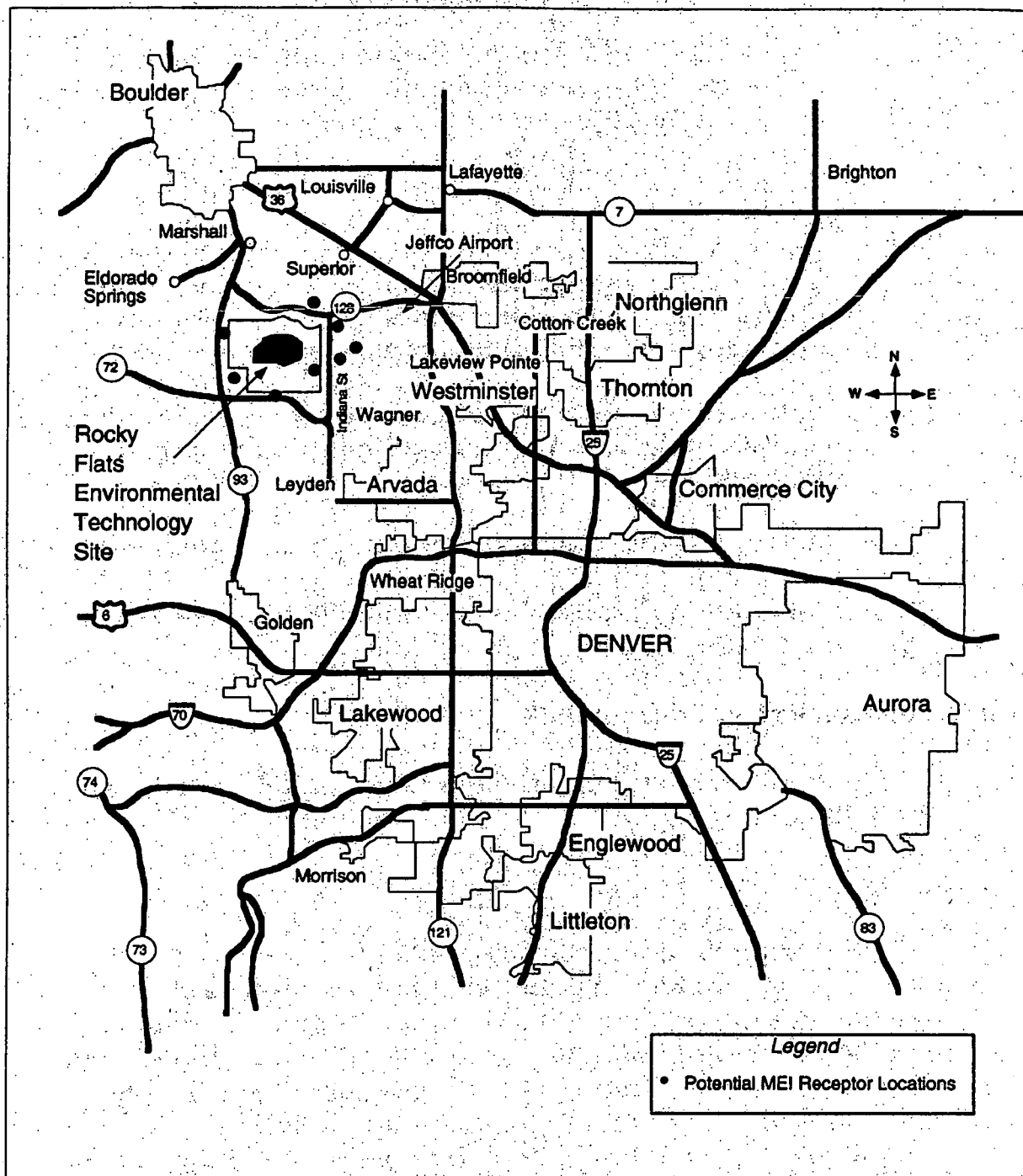
This section describes the dose model input data used to calculate EDE to the public for calendar year 1998.

4.2.2.1 Receptors

Compliance with the 10 mrem (0.1 mSv) public dose standard of 40 CFR 61.92 was determined by calculating the highest EDE to any member of the public at any off-Site point where there is a residence, school, business, or office. Modeling was performed for eight receptor locations, shown on Figure 4-2. These locations represent the residences, businesses, schools, and office buildings nearest the Site. Modeling determined that the maximally exposed individual (MEI) for 1998 was located at a distance of 3,686 m to the east-northeast of the central, industrial portion of the Site. The model input data described in the rest of Section 4.2.2 are those values used to calculate the MEI dose for 1998.

4.2.2.2 Point Source Input Data

Based on previous Site dose assessments and a comparison of 1998 emissions from various source categories, it was expected that routine emissions from point sources at



the Site would contribute a small amount to the total 1998 dose. Therefore, to streamline the modeling analysis, all 1998 point source emissions were conservatively combined and modeled from a single location within the central area of the Site. In addition, the radionuclide emissions from four nonpoint sources described in Section 2.2.2, installation of piping from the PIDAS steam pits to the sanitary sewer system, Building 371 loading dock installation, Solar Pond equipment removal/decontamination, and installation of cathodic protection to the North PIDAS Steam Line, were also included in the combined source due to the very small emissions generated by these projects and their close proximity to the point sources that were combined for the modeling analysis. The ongoing drum crushing operation near Building 984 was also included in the combined source.

The combined source emissions were modeled at the shortest actual point source release height using a conservative stack diameter (based on actual stack data) and an exit velocity characteristic of obstructed flow (such as would occur at a release point with a nonvertical stack or rain cap). Several sets of stack parameters were screened and the set that would result in the highest point source EDE to the public was used in the modeling analysis.

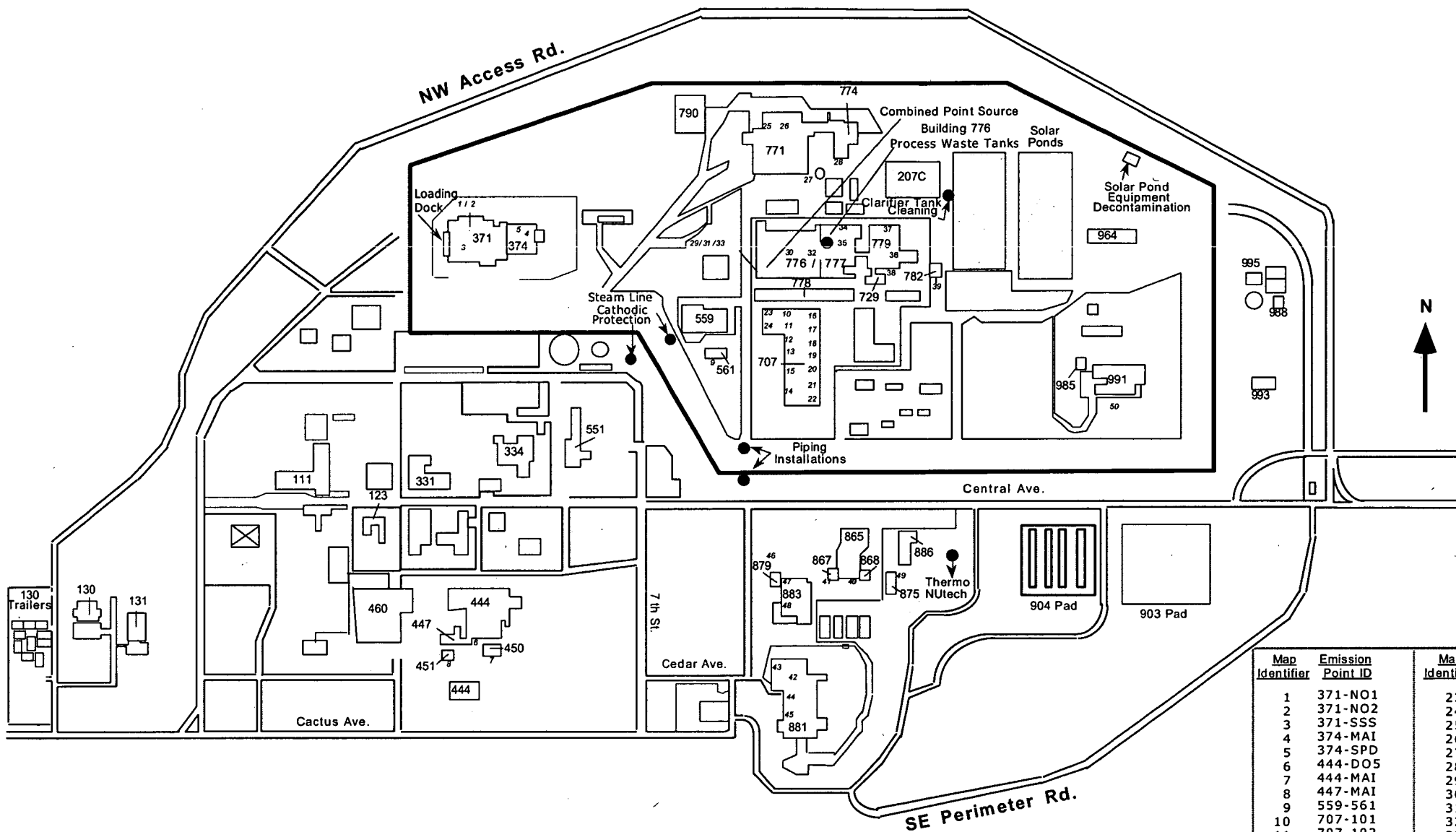
Figure 4-3 shows the location of individual emission sources that were combined for modeling purposes, as well as the location from which the combined emissions were modeled. Figure 4-3 also shows the building location from which calculated tritium emissions occurred: Building 790. Table 4-2 shows the release characteristics for the combined emissions source and the calculated tritium emissions.

Detailed information regarding the characteristics of individual release points is given in Appendix C.

4.2.3 Nonpoint Source Input Data

As described in Section 3.1, emissions from wind resuspension of contaminated soil were estimated based on surface soil radionuclide concentration isopleths for the Site that have been developed based on a Site-specific soil sampling database, combined with geographic information system (GIS) software. The GIS was used to compute the area of each isopleth, the centroid of each isopleth (representing the center of mass of the radionuclide contamination), and the distances from each centroid to each receptor. The area of each isopleth and the distance and direction to the MEI receptor are shown in Tables 4-3 through 4-7 for each of the isotopes modeled.

CAP88-PC simulates each nonpoint source as a point source at the centroid of the source area. The location of the individual nonpoint (area) sources that were modeled representing the T-1 source removal, the Mound Site Plume treatment system, the



not to scale
Revision 3, February 1999

Figure 4-3. Industrial Area Source Locations

Map Identifier	Emission Point ID	Map Identifier	Emission Point ID	Map Identifier	Emission Point ID
1	371-NO1	23	707-R45A/B	45	881-MA4
2	371-NO2	24	707-R46A/B	46	883-AAA
3	371-SSS	25	771-CMA	47	883-BBB
4	374-MAI	26	771-CRM	48	883-CCC
5	374-SPD	27	771-MAI	49	886-875
6	444-DO5	28	774-202	50	Drum Crushing
7	444-MAI	29	776-201		
8	447-MAI	30	776-202	Unmonitored Point Sources	
9	559-561	31	776-204	● Building 123 Decommissioning	
10	707-101	32	776-205	● Thermo NUtech	
11	707-102	33	776-250	● Building 776 Process Waste Tanks	
12	707-105	34	776-251	● Building 883 Tank Closure (883-BBB)	
13	707-106	35	776-252		
14	707-107	36	779-404	Area Sources	
15	707-108	37	779-405	● Building 371 Loading Dock	
16	707-R21A/B	38	779-729	● Steam Line Cathodic Protection	
17	707-R22A/B	39	779-782	● Steam Pit Piping Installation	
18	707-R23A/B	40	865-EEE	● Building 788 Clarifier Tank	
19	707-R24A/B	41	865-WWW	● Solar Pond Equipment Decontamination	
20	707-R25A/B	42	881-MA1		
21	707-R26A/B	43	881-MA2		
22	707-R27A/B	44	881-MA3		

Note:

Unmonitored tritium emissions occurred from Building 790.

Table 4-2. Source Data for Model Input—Point Sources

Parameter	Combined Sources ^a	Calculated Tritium Emissions
Height (m)	4.0	10.0
Diameter (m)	0.4	1.1
Exit Velocity (m/s)	0.1	8.3
Distance to MEI (m)	3,686	3,686
Direction to MEI	ENE	ENE

^a Includes measured point source emissions, as well as calculated emissions from the following point sources: Building 123 decommissioning, Building 776 process waste tanks, Thermo NUtech emissions, and Building 779 glovebox removal. This category also includes calculated emissions from the following nonpoint sources: installation of piping from the PIDAS steam pits to the sanitary sewer system, Building 371 loading dock installation, Solar Pond equipment removal/decontamination, installation of cathodic protection to the North PIDAS Steam Line, and the drum crushing operation.

Notes:

ENE = East-northeast
m = Meters
m/s = Meters per second
MEI = Maximally exposed individual

Table 4-3. Americium-241 Nonpoint Source Model Input Data^a

Isopleth No.	Area (m ²)	Distance to MEI (m) ^b	Direction to MEI ^b
Isopleth 1	87,631	3,281	ENE
Isopleth 2	3,139	3,292	ENE
Isopleth 3	1,089,835	2,618	ENE
Isopleth 4	13,377	3,264	ENE
Isopleth 5	7,059	3,412	ENE
Isopleth 6	2,570,045	1,533	ESE
Isopleth 7	1,200,884	2,177	NE
Isopleth 8	95,261	2,914	NE
Isopleth 9	93,077	3,059	NE
Isopleth 10	59,575	3,159	NE
Isopleth 11	51,672	3,252	NE

^a All isopleths were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity). Emissions are shown in Table 3-3.

^b From isopleth centroids.

Notes:

ENE = East-northeast
ESE = East-southeast
m = Meters

m² = Square meters
m/s = Meters per second
MEI = Maximally exposed individual
NE = North-east

Table 4-4. Plutonium-239/240 Nonpoint Source Model Input Data^a

Isopleth No.	Area (m ²)	Distance to MEI (m) ^b	Direction to MEI ^b
Isopleth 1	5,371,035	3,042	E
Isopleth 2	55,853	2,926	ENE
Isopleth 3	1,428,844	2,255	ESE
Isopleth 4	2,782,386	2,049	ESE
Isopleth 5	--	--	--
Isopleth 6	116,850	3,299	ENE
Isopleth 7	3,089	3,462	ENE
Isopleth 8	781,819	2,305	ESE
Isopleth 9	527,932	2,696	NE
Isopleth 10	84,642	3,143	NE
Isopleth 11	62,812	3,191	NE
Isopleth 12	74,507	3,192	NE
Isopleth 13	54,503	3,210	NE
Isopleth 14	4,027	4,325	ENE
Isopleth 15	13,276	4,045	ENE
Isopleth 16	48,787	3,231	NE
Isopleth 17	19,946	4,075	ENE
Isopleth 18	1,665	3,248	NE
Isopleth 19	18,343	3,078	E
Isopleth 20	9,419	4,993	E

^a All isopleths were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity). Emissions are shown in Table 3-3.

^b From isopleth centroids.

Notes:

-- = Not applicable
E = East
ENE = East-northeast
ESE = East-southeast
m = Meters
m² = Square meters
m/s = Meters per second
MEI = Maximally exposed individual
NE = North-east

Table 4-5. Uranium-233/234 Nonpoint Source Model Input Data^a

Isopleth No.	Area (m ²)	Distance to MEI (m) ^b	Direction to MEI ^b
Isopleth 1	9,893	3,278	ENE

^a All isopleths were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity). Emissions are shown in Table 3-3.

^b From isopleth centroids.

Notes:

ENE = East-northeast

m = Meters

m² = Square meters

m/s = Meters per second

MEI = Maximally exposed individual

Table 4-6. Uranium-235 Nonpoint Source Model Input Data^a

Isopleth No.	Area (m ²)	Distance to MEI (m) ^b	Direction to MEI ^b
Isopleth 1	61,275	3,321	ENE
Isopleth 2	908	3,541	ENE
Isopleth 3	19,734	4,349	ENE
Isopleth 4	8,105	3,862	ENE
Isopleth 5	16,683	2,694	S
Isopleth 6	82,668	2,640	S

^a All isopleths were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity). Emissions are shown in Table 3-3.

^b From isopleth centroids.

Notes:

ENE = East-northeast

m = Meters

m² = Square meters

m/s = Meters per second

MEI = Maximally exposed individual

S = South

Table 4-7. Uranium-238 Nonpoint Source Model Input Data^a

Isopleth No.	Area (m ²)	Distance to MEI (m) ^b	Direction to MEI ^b
Isopleth 1	6,323	2,687	S
Isopleth 2	1,842	4,369	ENE
Isopleth 3	27,479	2,660	S
Isopleth 4	5,270	2,687	S

^a All isopleths were modeled with heights of 0.0 m and no momentum plume rise (0.0 m/s exit velocity). Emissions are shown in Table 3-3.

^b From isopleth centroids.

Notes:

ENE = East-northeast

m = Meters

m² = Square meters

m/s = Meters per second

MEI = Maximally exposed individual

S = South

characterization of the 903 Pad and surrounding area, and the Building 788 clarifier tank draining are shown in Figure 4-4 (source input data for these sources are listed in Table 4-8). The soil resuspension isopleth centroid locations are shown in Figures 4-5 through 4-9. With the exception of T-1, nonpoint source emissions were simulated as ground level releases (height = 0.0 m) with no momentum plume rise (exit velocity = 0.0 meters per second [m/s]). The T-1 source was modeled using a height and exit velocity based on the vent fans in the roof of the weather shelter.

4.2.4 Meteorological Data

Meteorological data for calendar year 1998 were collected from a tower located in the western portion of the Site (the tower location is shown in Figure 4-4). A joint frequency distribution of wind speed, wind direction, and stability was processed for input to CAP88-PC. A "wind rose" graphic representation of the meteorological data is shown in Figure 4-10. Appendix D gives a detailed list of the joint frequency meteorological data for 1998. Annual precipitation and temperature data collected on Site for 1998 are summarized in Table 4-9. An average mixing height for the Denver, Colorado, area of 1,405 m was used in the model (EPA, 1972).

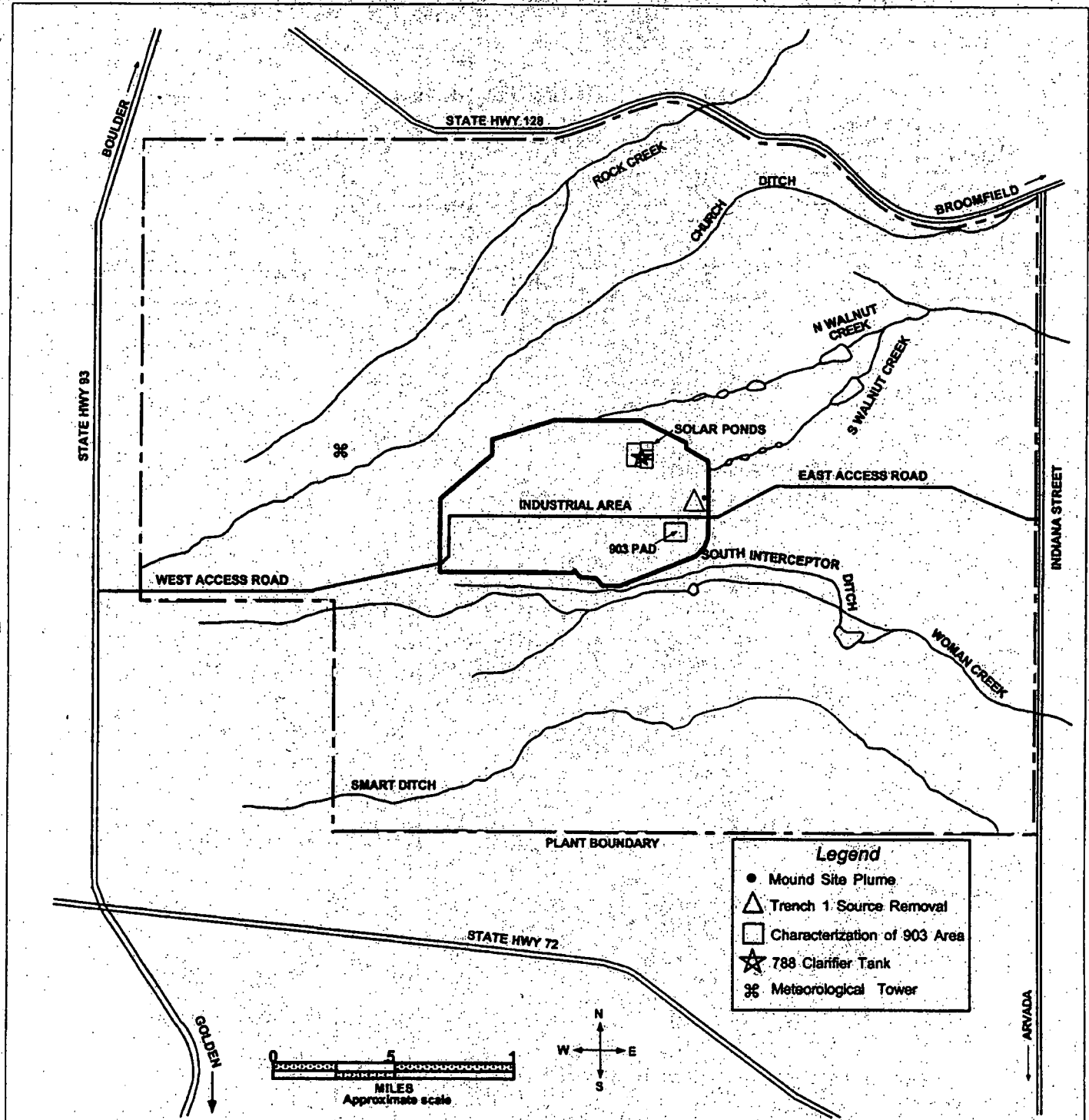


Figure 4-4. Project Emission and Meteorological Data Collection Locations

Table 4-8. Source Data for Model Input—Nonpoint Sources

Parameter	T-1 Source Removal	Mound Site Plume	Characterization Of 903 Area	Building 788 Clarifier Tank Draining
Height (m)	9.53	0	0	0
Area (m ²)	3,037	136	1,951	0
Exit Velocity (m/s)	3.45	0	0	0
Distance to MEI (m)	3,315	3,200	3,200	3,600
Direction to MEI	ENE	ENE	ENE	ENE

Notes:

ENE = East-northeast
m = Meters
m² = Square meters
m/s = Meters per second
MEI = Maximally exposed individual

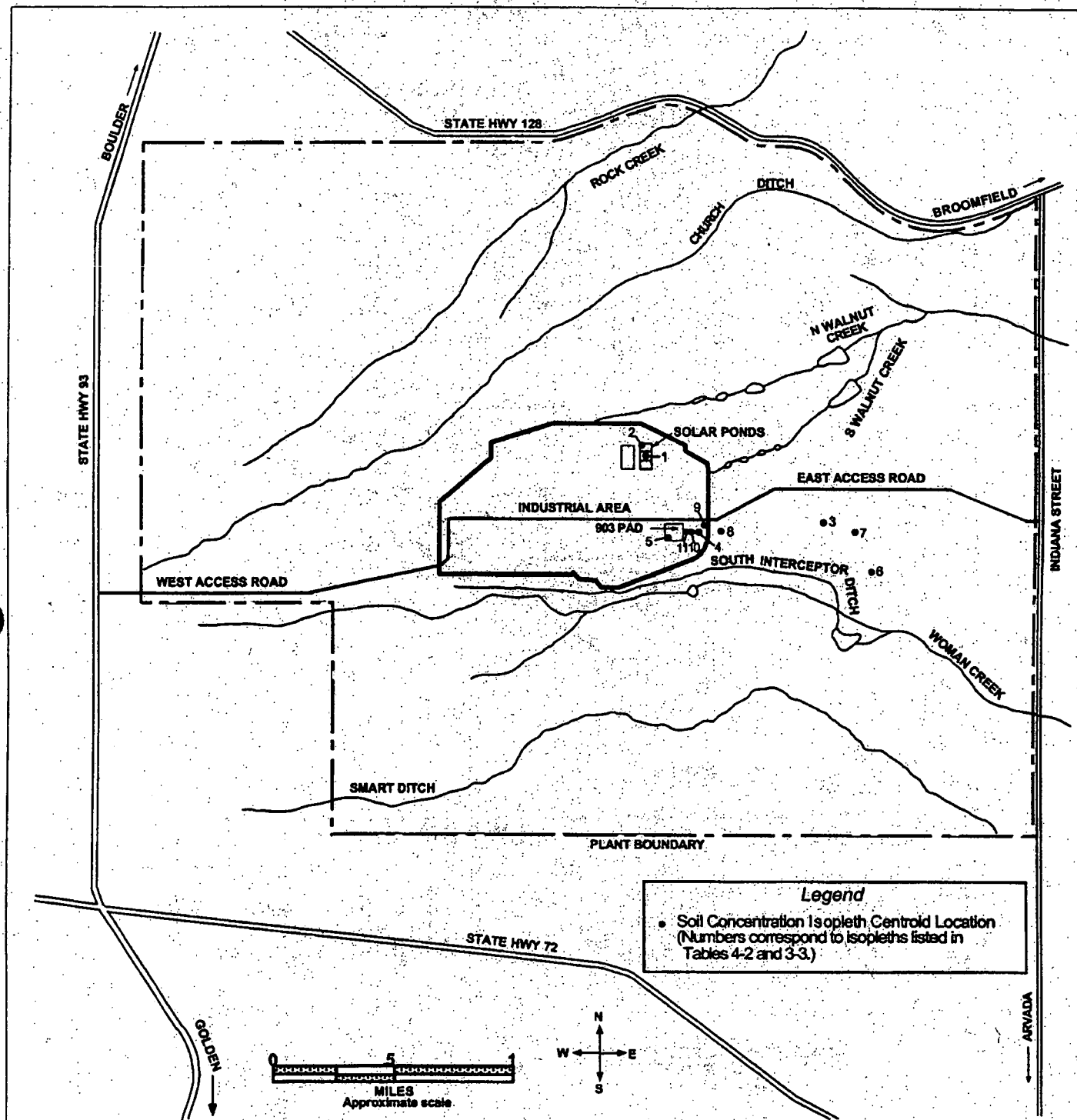


Figure 4-5. Soil Concentration Isopleth Centroid Locations for Americium-241

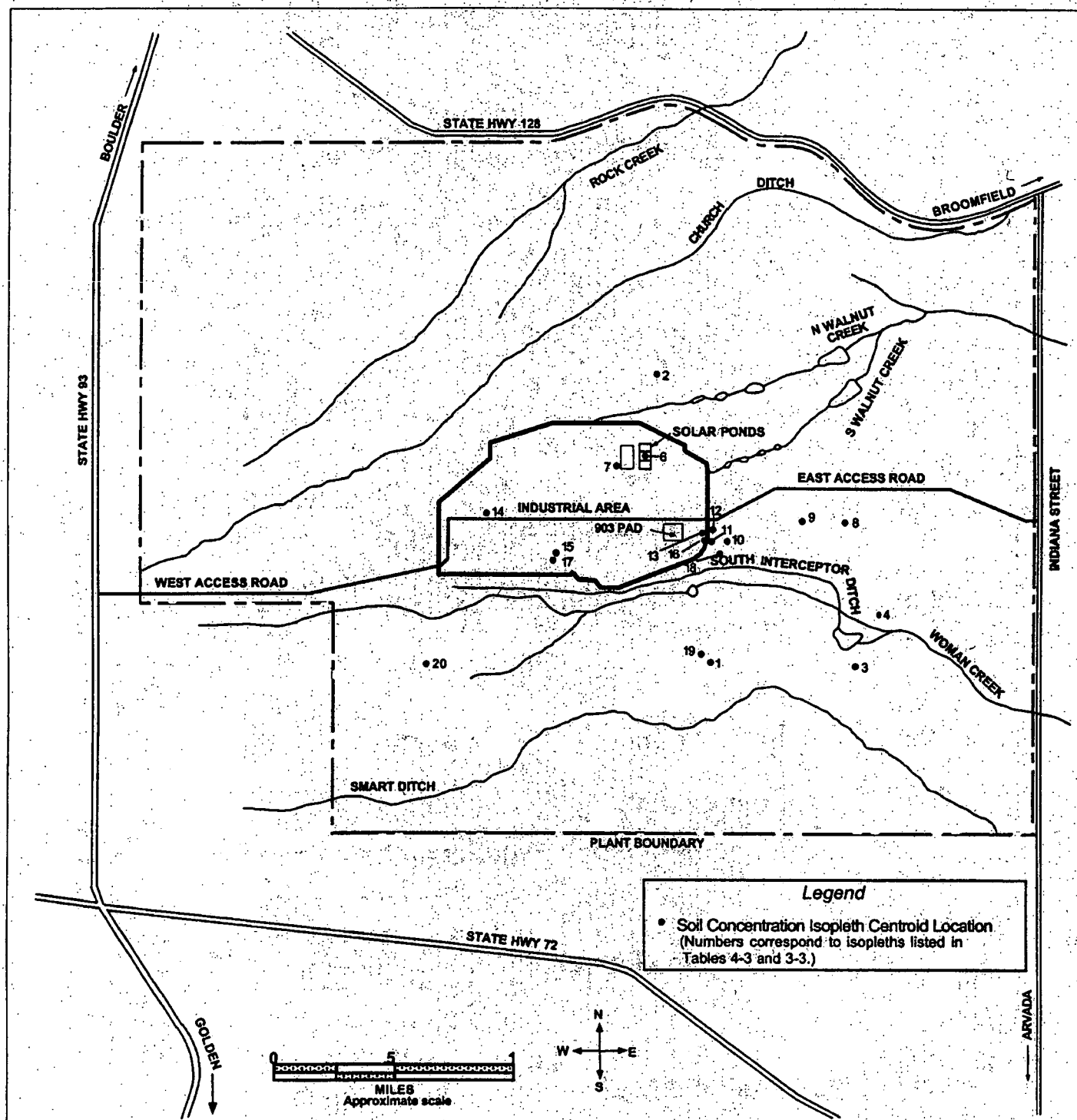


Figure 4-6. Soil Concentration Isopleth Centroid Locations for Plutonium-239 and Plutonium-240

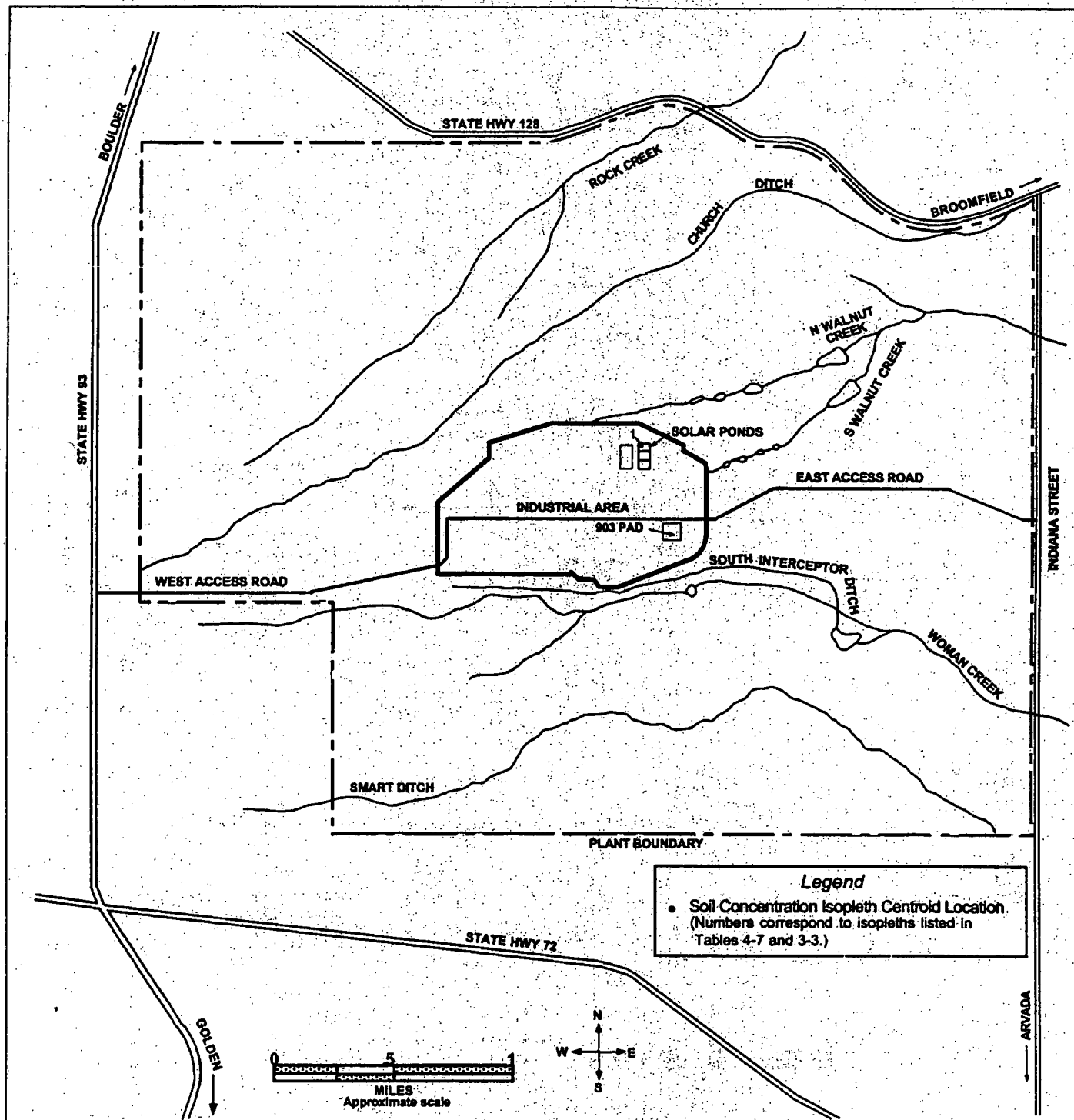


Figure 4-7. Soil Concentration Isopleth Centroid Locations for Uranium-233 and Uranium-234

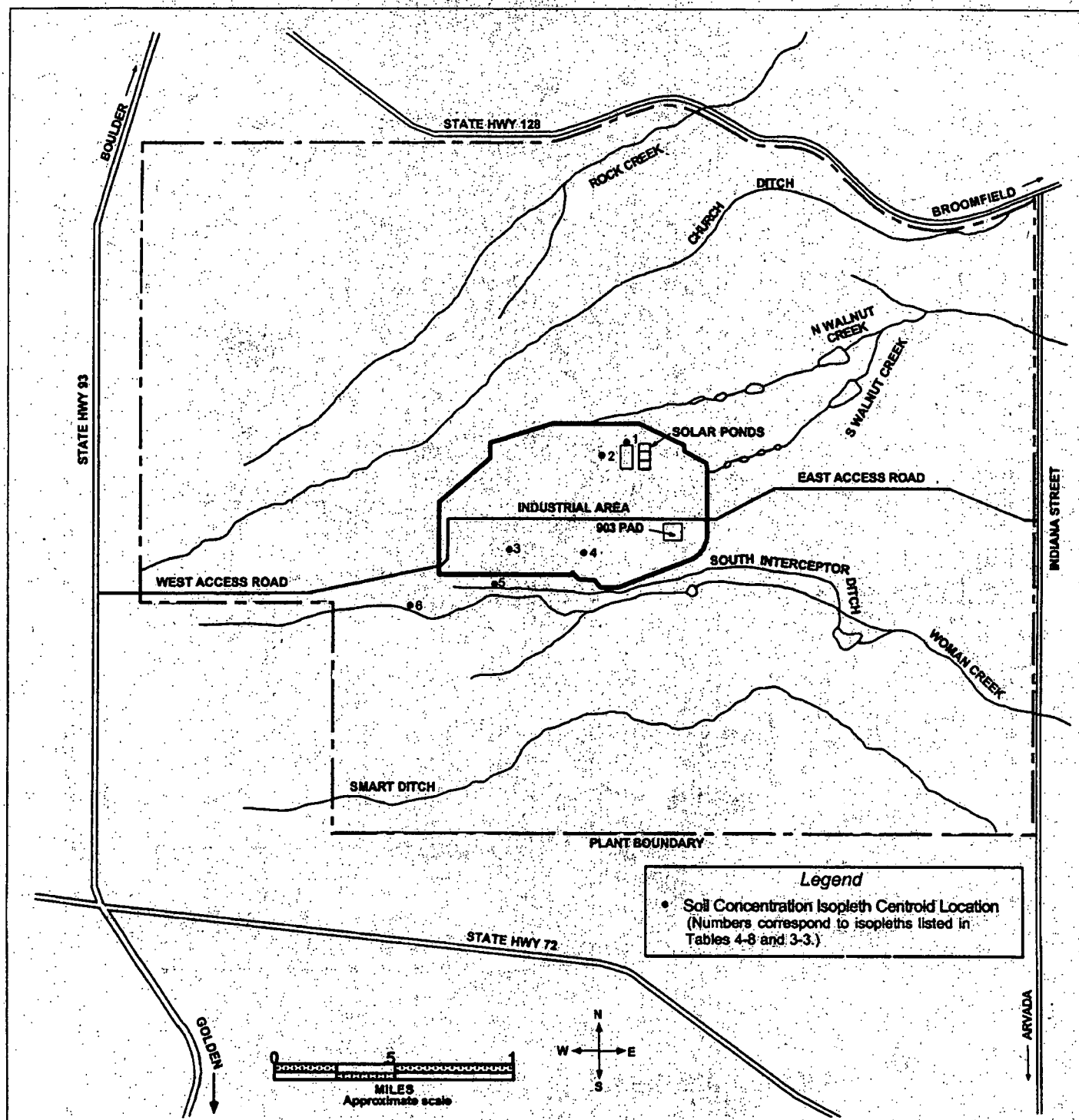


Figure 4-8. Soil Concentration Isopleth Centroid Locations for Uranium-235

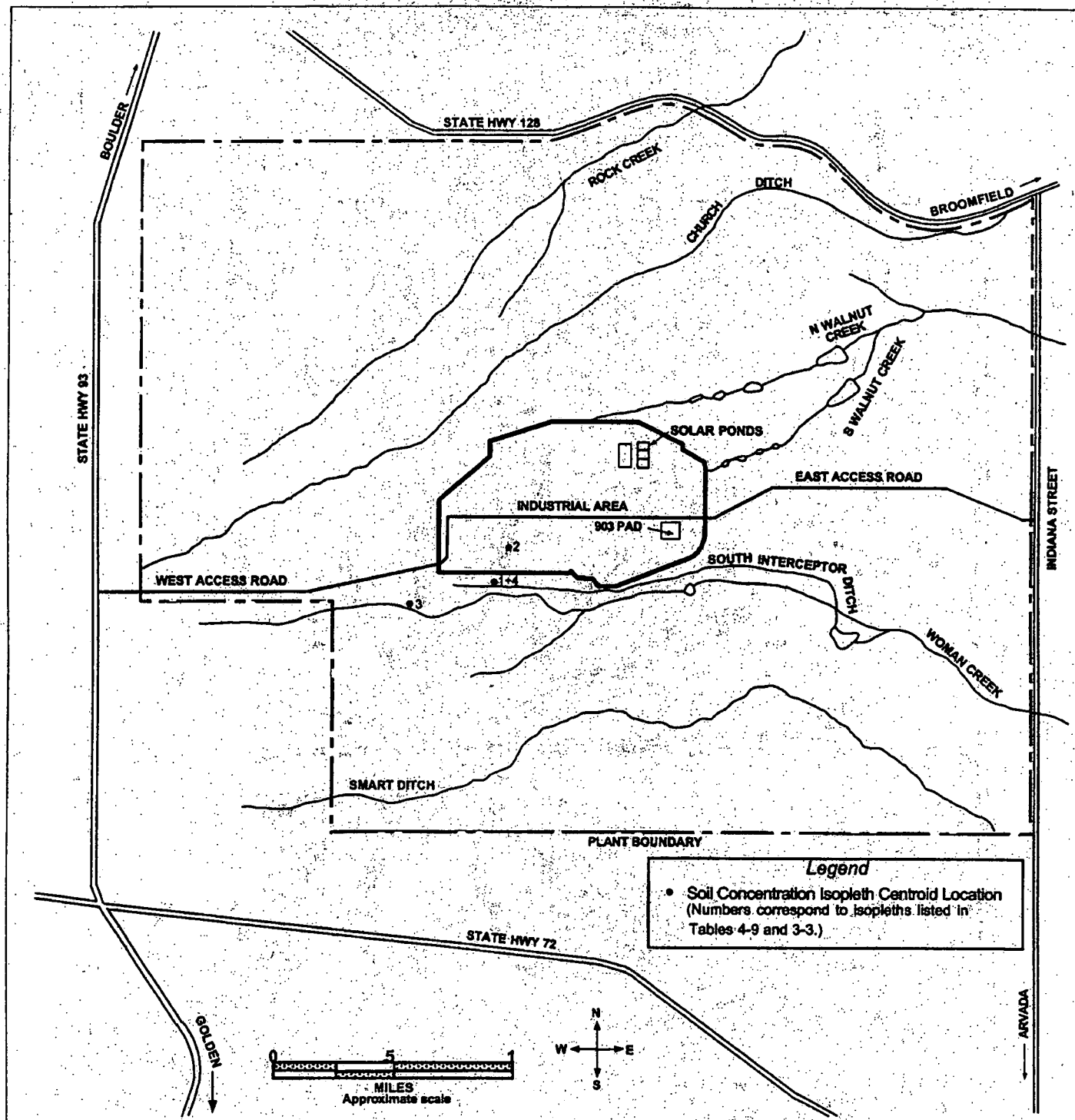


Figure 4-9. Soil Concentration Isopleth Centroid Locations for Uranium-238

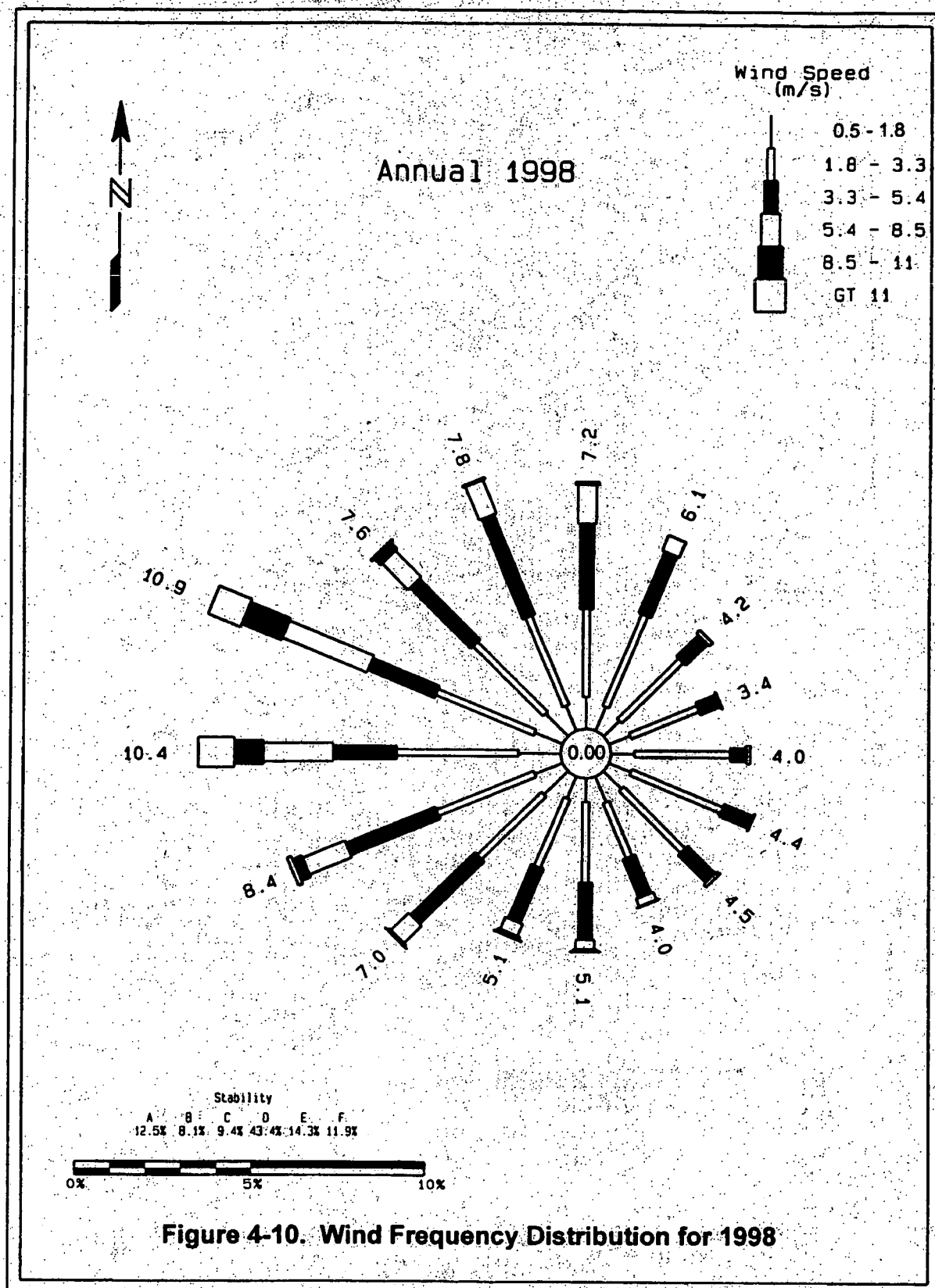


Table 4-9. Additional Meteorological Data for Model Input

Input	Value Used
Wind Data	From on-Site tower at 10 m height
Annual Precipitation ^a	36.60 cm
Annual Average Temperature ^b	10.8°C
Mixing Height ^c	1,405 m

^a Total precipitation equivalent for 1998 (rainfall and snowfall).

^b Average of monthly average temperatures.

^c Average of annual morning and afternoon mixing heights for Denver from Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States (EPA, 1972).

Notes:

cm = Centimeter

m = Meter

°C = Degrees Celsius

EPA = U.S. Environmental Protection Agency

4.2.5 Other Input Data

The CAP88-PC model also requires other input data. Model default values were used for the median aerodynamic diameter (1.0 micrometers [μm]) and solubility class. Urban agricultural data were used in the model and are shown in Table 4-10. Default values were also used for the origin of food products, as shown in Table 4-11.

The shortest distance between a Site radionuclide release point and farmland producing agricultural products is 720 m for beef cattle, 1,063 m for dairy cattle, and 1,063 m for cropland.

Appendix E summarizes the model input data used for this assessment.

4.3 Compliance Assessment Results

This section discusses the results of both the sampling-based and modeling-based compliance assessments that were performed for calendar year 1998.

4.3.1 Compliance Demonstration Based on Environmental Measurements

As reported in Section 4.1 of this report, the maximum annual concentrations of Pu-239, Am-241, U-233/234, U-235, and U-238 measured at the compliance sampler network were compared to the compliance levels listed in Table 2 of Appendix E to 40 CFR 61. In each case, the maximum measured concentration of each isotope, as

Table 4-10. Agricultural Data for Model Input

Input	Value Used
Source	Urban
Beef Cattle Density ^a	1.13 E-01 cattle/km ²
Milk Cattle Density ^a	3.50 E-03 cattle/km ²
Land Fraction Cultivated for Vegetable Crops ^a	1.39 E-02

^a Model default values.

Notes:

Km² = Square kilometers

E# = x 10[#]

Table 4-11. Origin of Food Products

Origin	Food Product		
	Vegetable	Milk	Beef
Fraction Home Produced ^a	0.076	0.0	0.008
Fraction From Assessment Area ^a	0.924	1.0	0.992
Fraction Imported ^a	0.0	0.0	0.0

^a Model default values.

shown in Table 4-1, was less than 1% of the corresponding compliance level. In addition, the fractional sum of all isotopes at the "critical receptor" location (the sampler showing the highest concentrations in 1998) was determined to be 0.0141. The facility is in compliance when the annual concentrations of each isotope are less than their corresponding Table 2 compliance levels and when the fractional sum of all isotopes is less than 1. (Note: Tritium is not measured at the compliance samplers; however, tritium dose calculated in the modeling analysis discussed in Section 4.3.2 would add less than 0.000000002 mrem.)

Figure 4-11 shows data from the 1998 compliance sampling network at all locations. The data are presented as percentages of the compliance level for each isotope; the total height of each bar in Figure 4-11 represents the fractional sum expressed as a percent of the allowable sum (percent of 1). Data are presented for each sampler, beginning with S-131 at the west gate of the Site, and continuing around the Site perimeter in a clockwise direction. Sampler locations are shown in Figure 4-1.

The maximum measured radionuclide levels occurred to the northwest of the Site, at sampler S-132. Nearly identical measured radionuclide levels occurred to the southeast of the Site as well, at sampler S-140. These two locations also showed the highest radionuclide levels measured at the perimeter samplers during calendar year 1997.

Examination of the isotopic data presented in Table 4-1 and Figure 4-11 shows that the higher overall radionuclide levels (fractional sums) at S-132 and S-140, relative to other samplers in the compliance network, were primarily due to higher levels of U-233/234 and U-238. U-233/234 and U-238 concentrations at these two samplers were at least half again as high as they were at any other location in the compliance sampling network (see Table 4-1). The concentration ratio of U-233/234 to U-238 activities at S-132 and S-140 (and at other compliance samplers as well) was approximately 1:1, which is characteristic of naturally occurring uranium. (In contrast, depleted or enriched uranium that might be emitted from on-Site sources would show either lower or higher isotopic ratios.) S-132 and S-140 are both located in areas that might be expected to show elevated dust levels due to traffic or quarrying activities. The soils surrounding Rocky Flats are rich in naturally occurring uranium, which may explain the elevated activities at these samplers.

Naturally occurring uranium isotopes appear to have dominated the airborne radionuclide levels at all the compliance samplers in 1998. In fact, the fraction of the compliance levels represented by U-233/234 and U-238 (which occurred at ratios close to the natural activity ratio of 1:1 at all compliance samplers) was an order-of-magnitude greater than that represented by the sum of the fractions of the other three radionuclides sampled (Pu-239, Am-241, and U-235).

Figure 4-12 shows the measured levels of Pu-239 and Am-241 at the compliance sampling network locations, also presented as percentages of the compliance level for each isotope. These two isotopes show the contribution of Site activities to airborne radionuclides and present a different pattern than U-233/234 and U-238. With respect to nonuranium isotopes, the data shown in Table 4-1, and Figures 4-11 and 4-12, indicate that maximum plutonium levels occurred at sampler S-137, located due east of the center of the Site. Based on annual average wind patterns (see Figure 4-10), sampler S-137 is generally downwind of the 903 Pad and surrounding areas, which represented the largest source of plutonium emissions on Site during 1998. Patterns are difficult to detect for other radionuclides or at other locations because the measured concentrations of nonuranium isotopes were quite low in 1998, hovering around background levels.

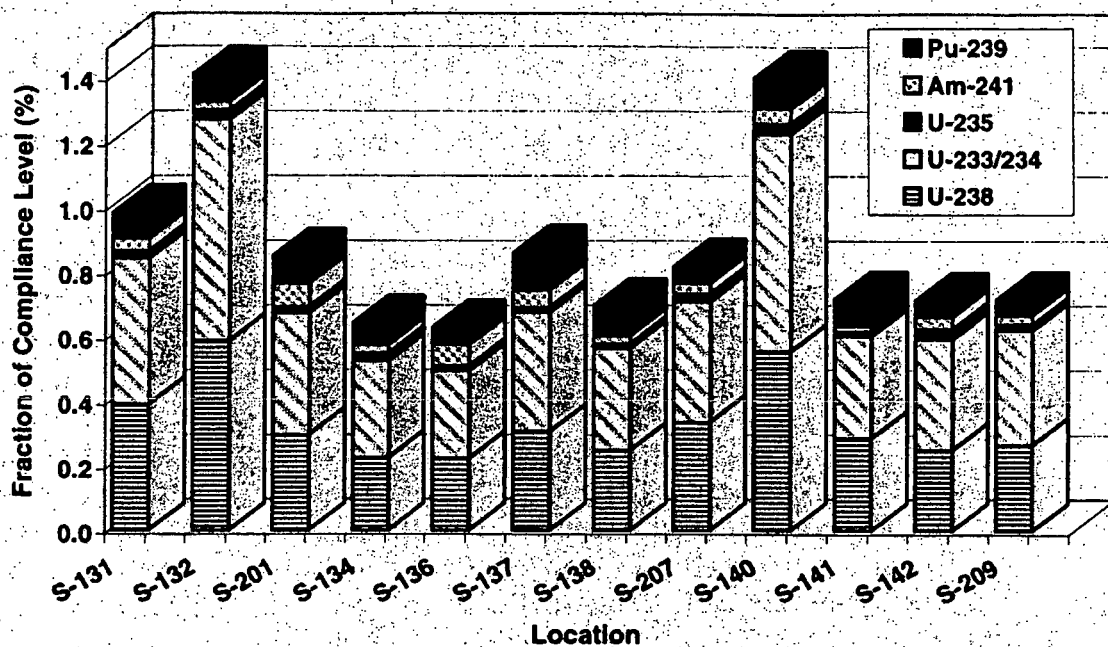


Figure 4-11. Environmental Measurements of Airborne Radionuclides in 1998

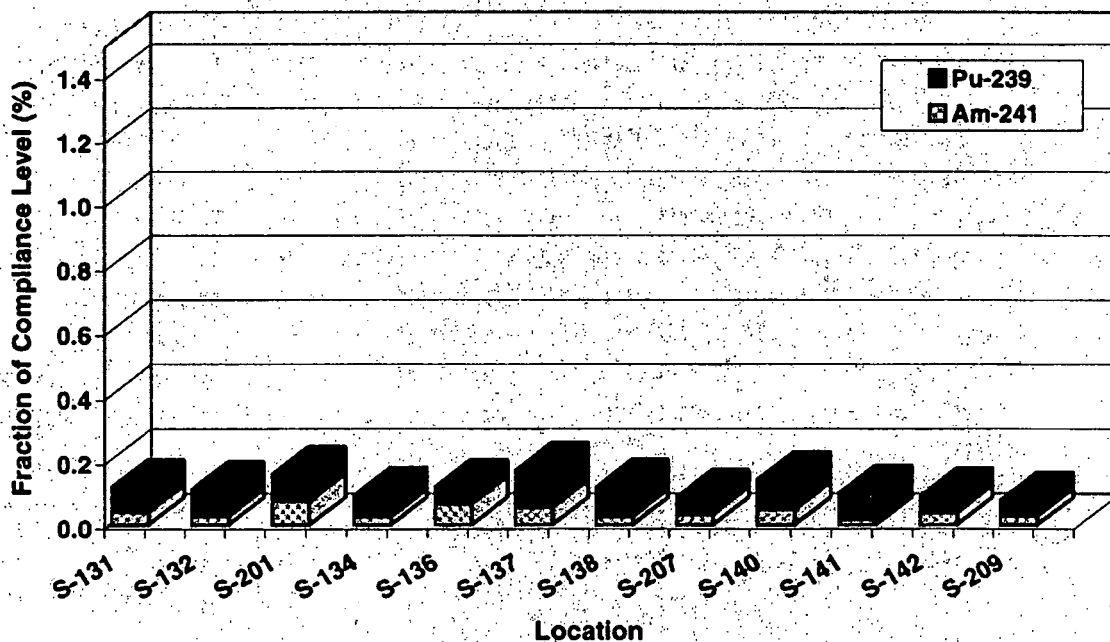


Figure 4-12. Environmental Measurements of Pu-239 and Am-241 in 1998

4.3.2 Compliance Demonstration Based on Modeling

The EDEs calculated for each modeled emission source were summed for each receptor and the MEI determined. The maximum off-Site calendar year 1998 EDE from all Site emissions was 0.041 mrem (0.00041 mSv), less than 0.5% of the 10 mrem (0.1 mSv) standard. The MEI was located at a new home site, approximately 3,686 m to the east-northeast of the center of the Site's industrial area.

The modeling-based dose calculation represents a 10-fold increase in maximum off-Site dose from calendar years 1997 and 1995 but a 10-fold decrease relative to 1996. The 1996 dose estimate primarily reflected the contributions of two projects that resulted in short-term, elevated radionuclide emissions. Calendar years 1995 and 1997, in contrast, had fairly routine emissions.

The dose estimate for 1998 is higher than 1995 and 1997 because of the estimated emissions from one project, the draining of the Building 788 clarifier tank. This highlights one of the limitations of the modeling method: where Site emissions occur from nonpoint activities, emissions must be estimated, rather than directly collected and quantified. In this case, emissions were calculated in a pre-project evaluation, using expected "worst case" project assumptions, combined with emission factors mandated by EPA for decision making regarding whether construction approval is needed for a given project. Those emission factors, along with the CAP88 model, are designed to be conservative; that is, to ensure that emissions and dose are not underestimated. In this case, the contribution from the clarifier tank project to the model-estimated dose was significantly overestimated. Project-specific ambient monitoring conducted during project activities using RAAMP samplers surrounding the project did not show comparable increases to those predicted in the modeling analysis.

The modeled contribution of various isotopes to dose was also heavily influenced by the assumptions that went into estimating emissions from the Building 788 clarifier tank draining. The emissions were estimated based on gross alpha screening data; all radioactivity was assumed to be due to americium because americium has the highest dose per unit activity of the major radionuclides present at the Site. This assumption ensured that dose would not be underestimated and also resulted in americium dominating the modeled dose.

The location of maximum impact also differed from previous years. In general, there has been a shift in the MEI as new residences or businesses have moved closer to the Site. The maximally exposed receptor location for 1998 was to the northeast of the Site, at the location of a new residence. Similarly, the maximum receptor last year was at a location that had not been present in previous years.

4.3.3 Comparison of Compliance Demonstrations

The two compliance demonstrations performed for this report showed somewhat different information about public dose for calendar year 1998. While both methods demonstrated that the potential off-Site dose due to Site activities was well within the 10 mrem standard, the results differed in terms of the magnitude and location of the maximum potential dose, as well as the isotopic breakdown of the EDE.

The measurement-based demonstration suggests a higher overall potential dose than the modeling demonstration (equivalent to approximately 0.141 mrem dose, compared to 0.041 mrem from modeling). As noted earlier, the measured concentration has a large contribution from naturally occurring uranium isotopes that is excluded from the model estimates. As a result, the locations of maximum potential dose also differed between the two demonstrations. The measured maximum concentration occurred to the southeast and northwest of the Site, in locations where local dust sources would affect measured concentrations. The MEI location, as determined by modeling, occurred at the closest receptor in the predominant downwind direction from the center of the Site (to the east-northeast).

Isotopic breakdown of dose was similarly affected. The measured dose showed a large (naturally occurring) uranium component that was not seen in the model estimates. The modeled dose, in turn, showed a large americium component due to conservative assumptions made in generating emission estimates for the Building 788 clarifier tank draining project.

4.3.4 Statement of Compliance Status

Compliance with the 10 mrem standard has been determined by comparing environmental radionuclide air concentration measurements at critical receptor locations with the "Concentration Levels for Environmental Compliance" listed in Table 2 of Appendix E to 40 CFR 61. Compliance is demonstrated when each measured radionuclide air concentration is less than its corresponding compliance level in Table 2 and when the "fractional sum" of all radionuclides is less than 1. For 1998, each measured radionuclide air concentration was less than 1% of its corresponding compliance level and the fractional sum of all radionuclides was less than 1.5% of the allowable level at all sampling locations. The Site was in compliance with the 10 mrem standard during 1998.

Compliance is demonstrated through emission measurement and modeling when the maximum annual EDE to any member of the public is less than 10 mrem. For 1998, the EDE at the MEI location was 0.041 mrem. Based on this information, the Site was in compliance with the 10 mrem standard during 1998.

4.4 Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. (See 18 USC 1001.)

Joseph A. Legare
Assistant Manager
for Environment and
Infrastructure

David C. Shelton
Vice-President, Environmental Systems and
Stewardship
Kaiser-Hill Company, L.L.C.

Signature

Date

Signature

Date

5.0 SUPPLEMENTAL INFORMATION

The following information is provided pursuant to DOE guidance or EPA request and is not required by 40 CFR 61, Subpart H, reporting requirements.

- **Calendar year 1998 dose at non-MEI locations:** The maximum EDE to the public for calendar year 1998 was 0.041 mrem (0.00041 mSv) for a receptor at a new house site located 3,686 m to the east-northeast of the center of the Site. Annual EDE estimates for the closest receptor locations in other directions from the center of the Site are shown in Table 5-1 for comparison.
- **Calendar year 1998 collective dose:** The collective dose to the surrounding population was calculated with CAP88-PC using population figures that were adjusted from 1994 data based on regional growth information. The collective dose represents the total dose to the surrounding population within 52 miles (83.7 km) of the Site. The collective dose for calendar year 1998 was 6.48 person-rem (0.0648 person-Sv).
- **Other radionuclide regulations:** 40 CFR 61, Subparts T and Q (CAQCC Regulation No. 8, Part A, Subparts T and Q) are not applicable to this Site. Subparts T and Q contain standards for radon emissions from specific facilities.
- **Unplanned releases:** There were no unplanned releases of radionuclides to the atmosphere from the Site during 1998.
- **Sitewide modeling/environmental measurement data comparison for calendar year 1998:** As discussed previously, the Site is transitioning to an alternative compliance demonstration method for 40 CFR 61, Subpart H that is based on environmental sampling, rather than emission measurement and modeling. Under the alternative compliance demonstration method, compliance with the 10 mrem (0.1 mSv) annual standard is assessed by comparing concentrations of individual isotopes measured at the Site boundary to compliance levels for each isotope listed in Table 2 of Appendix E to 40 CFR 61 and by summing fractional values of compliance levels for each isotope. Compliance is demonstrated if the measured concentration for each individual isotope is less than the concentration level listed in Table 2 of Appendix E and if the sum of the fractional values is less than 1.

For 1998, several comparisons have been made between the alternate compliance demonstration method and the historical, modeling-based approach. Measured concentrations of various individual isotopes and the summed fractional values of all isotopes are compared in Table 5-2 with the corresponding modeled estimates at the nearest receptor locations. Table 5-2 also shows the measured concentrations and fractional sum at the perimeter sampler with the largest

**Table 5-1. Calendar Year 1998 Dose at
Receptor Locations Surrounding Site**

Location	1998 EDE (mrem)	Distance to Receptor^a (m)	Direction to Receptor^a
Northeast Residence (MEI)	0.041	3,686	ENE
Mower Reservoir	0.034	4,143	ESE
McCaslin Boulevard	0.032	4,425	NE
East of Great Western Reservoir	0.027	5,695	E
96 th and Indiana	0.034	4,064	SE
Sawmill, east of Highway 93	0.017	2,994	WNW
South, at Highway 72	0.026	3,419	S
Rocky Flats Lake	0.013	3,625	SW

^a From center of Site industrial area.

Notes:

E = East
 EDE = Effective dose equivalent
 ENE = East-northeast
 ESE = East-southeast
 m = Meters
 MEI = Maximally exposed individual
 mrem = Millirem
 NE = Northeast
 S = South
 SE = Southeast
 SW = Southwest
 WNW = West-northwest

Table 5-2. Calendar Year 1998 Measured and Modeled Concentrations

Paired Locations ^a	Isotope	Compliance Level (Ci/m ³)	Measured Concentration (Ci/m ³)	Modeled Concentration (Ci/m ³)
S-137 (Measured) East of Great Western Reservoir (Modeled)	Pu-239	2.0 E-15	2.31 E-18	4.4E-19
	U-233/234	7.1/7.7 E-15	2.63 E-17	1.5E-19
	U-235	7.1 E-15	1.08 E-18	1.0E-19
	U-238	8.3 E-15	2.54 E-17	1.5E-19
	Am-241	1.9 E-15	1.03 E-18	5.4E-18
	Fractional Sum	1	0.00861	--
S-138 (Measured) Mower Reservoir (Modeled)	Pu-239	2.0 E-15	1.85 E-18	6.5E-19
	U-233/234	7.1/7.7 E-15	2.25 E-17	2.3E-19
	U-235	7.1 E-15	9.12 E-19	1.3E-19
	U-238	8.3 E-15	2.06 E-17	2.2E-19
	Am-241	1.9 E-15	4.84 E-19	6.9E-18
	Fractional Sum	1	0.00696	--
S-207 (Measured) 96 th and Indiana (Modeled)	Pu-239	2.0 E-15	1.08 E-18	6.5E-19
	U-233/234	7.1/7.7 E-15	2.66 E-17	2.3E-19
	U-235	7.1 E-15	1.65 E-18	1.4E-19
	U-238	8.3 E-15	2.78 E-17	2.1E-19
	Am-241	1.9 E-15	6.21 E-19	6.9E-18
	Fractional Sum	1	0.00819	--
S-141 (Measured) South, at Highway 72 (Modeled)	Pu-239	2.0 E-15	1.67 E-18	3.8E-19
	U-233/234	7.1/7.7 E-15	2.25 E-17	1.6E-19
	U-235	7.1 E-15	1.05 E-18	1.1E-19
	U-238	8.3 E-15	2.38 E-17	1.5E-19
	Am-241	1.9 E-15	3.10 E-19	5.2E-18
	Fractional Sum	1	0.00718	--
S-142 (Measured) South, at Highway 72 (Modeled)	Pu-239	2.0 E-15	1.05 E-18	3.8E-19
	U-233/234	7.1/7.7 E-15	2.44 E-17	1.6E-19
	U-235	7.1 E-15	2.16 E-18	1.1E-19
	U-238	8.3 E-15	2.07 E-17	1.5E-19
	Am-241	1.9 E-15	7.20 E-19	5.2E-18
	Fractional Sum	1	0.00715	--
S-209 (Measured) Rocky Flats Lake (Modeled)	Pu-239	2.0 E-15	9.83 E-19	1.7E-19
	U-233/234	7.1/7.7 E-15	2.52 E-17	7.5E-20
	U-235	7.1 E-15	1.29 E-18	5.2E-20
	U-238	8.3 E-15	2.21 E-17	7.0E-20
	Am-241	1.9 E-15	5.31 E-19	2.4E-18
	Fractional Sum	1	0.00717	--
S-132 (Measured) Sawmill, east of Highway 93 (Modeled)	Pu-239	2.0 E-15	1.69 E-18	2.1E-19
	U-233/234	7.1/7.7 E-15	4.85 E-17	1.0E-19
	U-235	7.1 E-15	2.04 E-18	7.2E-20
	U-238	8.3 E-15	4.87 E-17	9.2E-20
	Am-241	1.9 E-15	5.06 E-19	3.3E-18
	Fractional Sum	1	0.0141	--

Table 5-2. (Continued)

Paired Locations ^a	Isotope	Compliance Level (Ci/m ³)	Measured Concentration (Ci/m ³)	Modeled Concentration (Ci/m ³)
S-134 (Measured) McCaslin Boulevard (Modeled)	Pu-239	2.0 E-15	1.36 E-18	4.6E-19
	U-233/234	7.1/7.7 E-15	2.13 E-17	2.0E-19
	U-235	7.1 E-15	1.76 E-18	1.3E-19
	U-238	8.3 E-15	1.87 E-17	1.9E-19
	Am-241	1.9 E-15	4.76 E-19	6.7E-18
	Fractional Sum	1	0.00643	--
S-136 (Measured) McCaslin Boulevard (Modeled)	Pu-239	2.0 E-15	1.05 E-18	4.6E-19
	U-233/234	7.1/7.7 E-15	1.92 E-17	2.0E-19
	U-235	7.1 E-15	1.12 E-18	1.3E-19
	U-238	8.3 E-15	1.86 E-17	1.9E-19
	Am-241	1.9 E-15	1.25 E-18	6.7E-18
	Fractional Sum	1	0.00628	--
S-136 (Measured) Northeast Residence (Modeled)	Pu-239	2.0 E-15	1.05 E-18	6.6E-19
	U-233/234	7.1/7.7 E-15	1.92 E-17	2.7E-19
	U-235	7.1 E-15	1.12 E-18	1.6E-19
	U-238	8.3 E-15	1.86 E-17	2.5E-19
	Am-241	1.9 E-15	1.25 E-18	8.4E-18
	Fractional Sum	1	0.00628	--
Critical Receptor: S-132 (Measured) MEI (Modeled)	Pu-239	2.0 E-15	1.69 E-18	6.6E-19
	U-233/234	7.1/7.7 E-15	4.85 E-17	2.7E-19
	U-235	7.1 E-15	2.04 E-18	1.6E-19
	U-238	8.3 E-15	4.87 E-17	2.5E-19
	Am-241	1.9 E-15	5.06 E-19	8.4E-18
	Fractional Sum	1	0.0141	--

^a Locations of receptors and samplers are shown in Figure 5-1.

^b Compliance levels are the standards given in Table 2, Appendix E, 40 CFR 61.

Notes:

Am = Americium

Pu = Plutonium

CFR = Code of Federal Regulations

Ci/m³ = Curies per cubic meter

E# = x 10[#]

MEI = Maximally exposed individual

U = Uranium

-- = Not applicable

fractional sum in 1998 (i.e., the "critical receptor") and compares these values with the concentrations estimated through modeling for the MEI. Figure 5-1 shows the locations of the perimeter samplers and receptors.

Table 5-2 shows some consistent patterns at all locations. In general, U-233/234 and U-238 concentrations were two to three orders of magnitude higher in the measured data compared with modeled values. This is consistent with previous years and reflects the contribution of naturally occurring uranium. U-235 was also higher in the measured data and again may reflect an additional component of natural background.

Other patterns were apparent in the nonuranium isotopes. Pu-239 concentrations produced by the modeling analysis were less than measured values at all locations, while Am-241 concentrations were higher in the modeling results. These patterns may indicate a different distribution of isotopes emitted by the Building 788 clarifier tank draining or other projects relative to the assumptions made for the modeling analysis.

If measured concentrations are converted to dose units using the allowable concentrations given in Table 2 of Appendix E to 40 CFR 61 as conversion factors, the maximum dose measured at the perimeter of the Site was approximately 0.141 mrem in 1998. In contrast, the modeled MEI dose was 0.041 mrem. U-233/234 and U-238 isotopes contributed approximately 90% of the maximum measured dose but only 1.3% of the modeled dose. Inspection of the U-233/234 to U-238 ratios in the measured data indicate that most of the uranium measured was naturally occurring. The measured dose due to plutonium and americium isotopes at the critical receptor was approximately 0.0111 mrem, compared to the total modeled contributions for those isotopes at the MEI location of 0.0405 mrem.

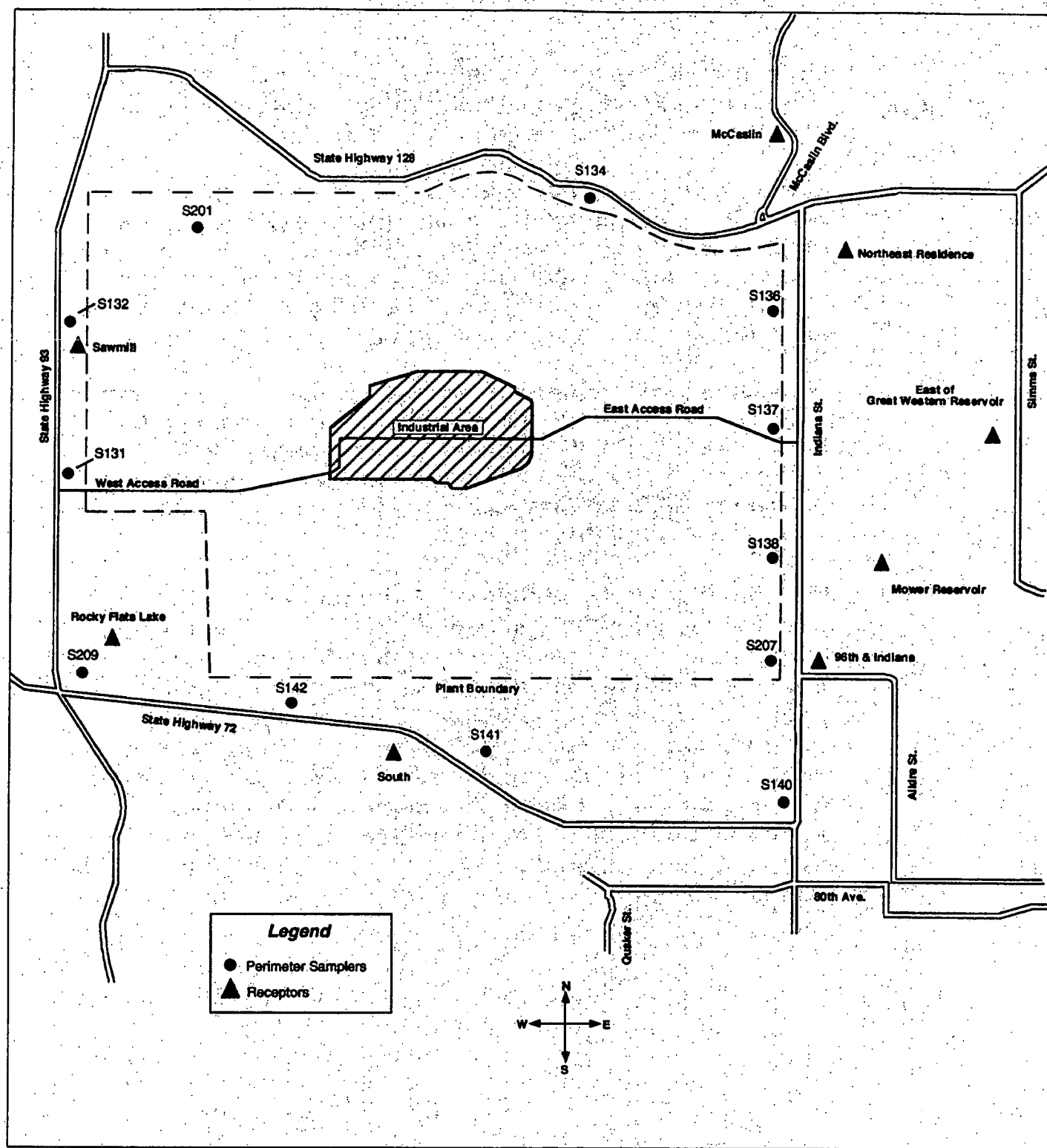


Figure 5-1. Receptor Locations and Nearby Samplers

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Appendix A

Radioactive Materials Associated with Rocky Flats

ROCKY FLATS HEALTH PHYSICS REPORT
RADIOACTIVE MATERIALS
ASSOCIATED WITH
ROCKY FLATS

October 31, 1995

B. Britton
Source Registry Program Administrator
303/966-8452

A. RADIOACTIVE MATERIALS HANDLED IN KILOGRAM QUANTITIES

1. Plutonium

Isotopic Composition of Rocky Flats Plutonium

<u>Isotope</u>	<u>Relative Weight (percent)</u>	<u>Specific Alpha Activity (Curies/gram)</u>	<u>Specific Beta Activity (Curies/gram)</u>	<u>Relative Activity (Curies/gram)^a</u>
Pu-238	0.01	17.01	---	0.00171
Pu-239	93.79	0.0622	---	0.05834
Pu-240	5.80	0.228	---	0.01322
Pu-241	0.36	---	103.5	0.37260
Pu-242	0.03	0.00393	---	1.18x10 ⁻⁶
Am-241	^b	3.42	---	---

^a Relative activity is obtained by multiplying the percent by weight by the specific activity. The total activity for the Plutonium Isotopes is: Alpha, 0.0732 curies/gram; and Alpha plus Beta, 0.446 curies/gram.

^b Am-241 is a radioactive decay product of Pu-241.

2. Enriched Uranium

Common Name: Oralloy
Normal Isotopic Composition: >90% U-235

3. Depleted Uranium

Common Names: Tuballoy, D-38, U-238
Normal Isotopic Composition: <0.71%, U-235

4. Americium (Am-241)

Am-241 is a radioactive decay product of Pu-241.

5. Natural Uranium (Thorium and Uranium-233)

Rocky Flats has both the capability and potential to handle these in kilogram quantities. Some of these materials have been handled in the past.

B. RADIOACTIVE MATERIALS HANDLED IN GRAM QUANTITIES (<1Kg)

Curium-244
Neptunium-237
Uranium-233
Plutonium-238,-242

These radioisotopes may be handled at Rocky Flats primarily for research and analytical activities.

C. RADIOISOTOPES UTILIZED AT ROCKY FLATS AS REGISTERED AND/OR MISCELLANEOUS SOURCES

1. Registered Sources (Twice-Yearly Leak Test and Physical Audit)

Sealed solids >10 μ Ci
Plated solids >1 μ Ci
Liquids > 10^{-3} μ Ci

Americium	(Am-241)	Iridium	(Ir-192)
Antimony	(Sb-124)	Iron	(Fe-55)
Barium	(Ba-133)	Nickel	(Ni-63)
Cadmium	(Cd-109)	Plutonium	(Pu-238,-239, -240,-244)
Californium	(Cf-252)	Promethium	(Pm-147)
Cesium	(Cs-137)	Radium	(Ra-226)
Cobalt	(Co-57,60)	Selenium	(Se-75)
Europium	(Eu-152)	Sodium	(Na-22)
Hydrogen (Tritium)	(H-3)	Strontium	(Sr-90)
		Thorium	(Th-228)
		Uranium	(U-234,-235,-238)

2. Miscellaneous Sources

Sealed solids < 10 μ Ci
Plated solids < 1 μ Ci
Liquids < 10⁻³ μ Ci
Analytical stock solutions

Aluminum	(Al-26)	Lead	(Pb-210)
Americium	(Am-241,243)	Manganese	(Mn-54)
Antimony	(Sb-125)	Mercury	(Hg-203)
Argon	(Ar-39)	Neptunium	(Np-237)
Barium	(Ba-133)	Plutonium	(Pu-236,-238,-239 -240,241,242)
Beryllium	(Be-7)	Polonium	(Po-210)
Bismuth	(Bi-207,-210)	Promethium	(Pm-147)
Cadmium	(Cd-109)	Radium	(Ra-226)
Californium	(Cf-252)	Ruthenium	(Ru-106)
Carbon	(C-14)	Selenium	(Se-75)
Cesium	(Cs-137)	Silver	(Ag-110m)
Chlorine	(Cl-36)	Sodium	(Na-22)
Cobalt	(Co-57,-60)	Strontium	(Sr86-90)
Curium	(Cm-244)	Technetium	(Tc-99m)
Europium	(Eu-152)	Thallium	(Tl-204)
Holmium	(Ho-166m)	Thorium	(Th-228,-230,-232)
Hydrogen (Tritium)	(H-3)	Tin	(Sn-113)
Iodine	(I-129,-131)	Uranium	(U-232, -234, 235, -236,-238)
Iron	(Fe-55)	Yttrium	(Y-88,-90)
Krypton	(Kr-85)	Zinc	(Zn-65)

D. RADIUM SOURCES HANDLED AND STORED AT ROCKY FLATS

<u>AS/RS*</u>	<u>EG&G ID</u>	<u>Nuclide</u>	<u>Location</u>	<u>Original Activity (μCi)</u>
AS	2934	Ra-226	119	0.09
RS	100	Ra-226	707	6.00000
RS	138	Ra-226	776	6.00000
RS	3695	Ra-226	881	6.26
RS	866	Ra-226	881	10.95
RS	810	Ra-226	771	11.26000
RS	409	Ra-226	371	12.5
RS	196	Ra-226	771	16
RS	23	Ra-226	777	4500
RS	146	Ra-226	777	4500

* AS = Accountable Source
RS = Registered Source

Appendix B

Effluent Information System (EIS) Data

Summary Table For The EIS/ODIS Report^a

1998-Release (Ci)

	ODIS		Effluent						
98_ODIS	Location		Volume	Plutonium	Americium	Uranium	Uranium	Uranium	Tritium
Location	Code	N	(m ³)	239	241	233/234	235	238	
707-101	AFGHB707005	12	8.566E+06	1.109E-10	1.240E-11	1.387E-10	6.946E-11	1.816E-10	--
707-102	AFGHB707006	12	2.170E+07	2.196E-10	2.187E-10	7.741E-10	2.043E-10	4.013E-10	--
707-105	AFGHB707003	12	7.548E+07	7.408E-10	-1.989E-10	2.762E-09	1.212E-09	1.356E-09	--
707-106	AFGHB707001	12	2.832E+07	4.611E-10	1.169E-10	1.079E-09	2.390E-10	6.107E-10	--
707-107	AFGHB707004	12	1.819E+08	1.039E-09	1.448E-09	8.297E-09	1.202E-09	1.136E-08	--
707-108	AFGHB707002	12	1.004E+08	1.014E-09	3.124E-10	3.534E-09	1.013E-09	2.720E-09	--
707-R21	AFGHI707001	1	4.453E+08	4.694E-10	-2.292E-09	6.513E-10	-4.018E-10	-3.180E-09	--
707-R22	AFGHI707002	1	4.453E+08	2.618E-09	8.881E-10	1.751E-09	1.692E-11	-1.104E-09	--
707-R23	AFGHI707003	1	4.453E+08	3.341E-10	-8.205E-10	-4.652E-11	-6.217E-10	-3.316E-09	--
707-R24	AFGHI707004	1	4.453E+08	9.389E-10	2.030E-10	-2.000E-09	-1.015E-10	-1.480E-09	--
707-R25	AFGHI707005	1	4.453E+08	2.030E-10	-1.226E-10	-2.229E-09	-1.184E-10	-3.920E-09	--
707-R26	AFGHI707006	1	4.453E+08	1.226E-10	-1.045E-09	-5.963E-10	4.610E-10	-3.349E-09	--
707-R27	AFGHI707007	1	4.453E+08	1.916E-09	-1.019E-09	-3.616E-09	-5.075E-11	-4.614E-09	--
707-R45	AFGHI707008	1	4.453E+08	8.458E-11	-9.854E-10	-2.550E-09	-2.538E-10	-3.180E-09	--
707-R46	AFGHI707009	1	4.453E+08	-2.495E-10	-4.060E-10	-2.034E-09	3.595E-10	-3.333E-09	--
779-782	AFGHF779002	12	6.170E+08	6.436E-09	9.996E-12	-1.015E-08	9.578E-10	-1.858E-08	--
779-729	AFGHF779001	12	1.658E+08	7.792E-10	-5.088E-10	-2.938E-09	4.076E-10	-3.229E-09	--
776-201	AFGHE776003	12	6.915E+06	3.917E-11	3.338E-11	1.944E-10	4.829E-11	1.768E-10	--
776-202	AFGHE776008	12	7.276E+07	9.027E-10	-5.400E-11	-1.419E-10	-7.093E-11	-5.094E-10	--
776-204	AFGHE776005	12	1.613E+08	6.663E-10	1.925E-09	9.291E-09	6.845E-10	6.287E-09	--
776-205 ^o	--	12	2.320E+08	3.116E-09	1.990E-09	4.611E-09	1.514E-09	4.259E-09	--
776-205T ^c	AFGHE776004		--	--	--	--	--	--	2.362E-06
776-206T ^c	AFGHE776002		--	--	--	--	--	--	1.805E-05
776-250	AFGHE776001	1	3.923E+08	3.992E-08	-3.843E-09	5.423E-09	-1.494E-09	-8.027E-09	6.773E-06
776-251	AFGHE776006	1	3.282E+08	8.405E-10	-1.681E-09	-1.350E-09	4.457E-11	-3.171E-09	5.642E-06
776-252	AFGHE776007	1	8.684E+07	6.829E-08	8.138E-09	-1.021E-10	-5.146E-11	-7.667E-10	--
559-561	AFGHA559001	12	5.898E+08	4.863E-09	-2.216E-09	7.593E-09	4.321E-09	1.051E-08	--
778-LDY	AFGHH778001	0	--	--	--	--	--	--	--
771-MAI	AFGHC771001	12	2.453E+09	1.457E-08	2.244E-11	2.964E-08	2.054E-08	1.187E-08	--
771-CMA	AFGHC771002	1	6.978E+07	4.880E-09	5.360E-10	-1.792E-10	-2.104E-11	-4.056E-10	--
771-CRM	AFGHC771005	1	8.486E+07	7.623E-09	1.767E-09	1.299E-10	8.078E-11	-6.795E-10	--
774-202	AFGHD774001	12	8.406E+07	1.478E-10	-8.560E-12	-7.615E-11	7.738E-10	-4.228E-10	--
444-MAI	AFGHN444004	1	1.346E+09	6.146E-09	-3.412E-09	-2.948E-09	1.041E-09	-1.162E-08	--
444-DO5	AFGHN444003	1	1.571E+08	1.898E-11	-6.330E-12	-8.919E-10	5.060E-11	-2.451E-09	--
447-MAI	AFGHO447001	1	7.556E+08	3.349E-10	-1.785E-09	-6.430E-09	-2.203E-10	-9.805E-09	--

(Continued)

	ODIS		Effluent						
98_ODIS	Location		Volume	Plutonium	Americium	Uranium	Uranium	Uranium	Tritium
Location	Code	N	(m ³)	239	241	233/234	235	238	
865-EEE	AFGHP865001	1	4.080E+08	2.100E-09	-1.308E-09	-5.014E-09	-3.628E-10	-7.970E-09	--
865-WWW	AFGHP865002	1	6.762E+08	-2.857E-10	-1.524E-10	-9.471E-09	-8.252E-11	-1.388E-08	--
886-875	AFGHS886001	1	1.162E+08	3.629E-10	8.592E-10	4.433E-10	3.923E-10	5.394E-10	--
881-ANX	AFGHQ881002	0	--	--	--	--	--	--	--
881-MAI	AFGHQ881001	4	3.923E+09	1.839E-08	-2.305E-08	3.257E-09	-2.825E-09	-3.502E-08	--
883-AAA	AFGHR883001	1	7.768E+08	1.339E-10	-8.166E-10	-7.704E-09	1.272E-10	1.647E-09	--
883-BBB	AFGHR883002	1	1.083E+09	1.313E-09	-1.387E-09	-9.298E-09	8.709E-11	-1.259E-08	--
883-CCC	AFGHR883003	1	2.348E+08	1.119E-09	-1.924E-09	-7.956E-09	-7.228E-10	-2.940E-09	--
889-MAI	AFGHT889001	0	--	--	--	--	--	--	--
991-985	AFGHU991001	0	--	--	--	--	--	--	--
374-MAI	AFGHJ374001	12	3.353E+08	3.196E-09	1.121E-09	2.676E-09	6.028E-10	-7.736E-10	--
991-MAI	AFGHU991002	0	--	--	--	--	--	--	--
371-NNN	AFGHC371001	24	5.242E+08	1.838E-08	1.245E-09	-9.648E-09	2.842E-09	-1.300E-08	--
371-SSS	AFGHC371002	12	2.990E+08	6.923E-10	-4.174E-10	-2.557E-09	3.109E-10	-3.439E-09	--
374-SPD	AFGHD374002	1	8.737E+07	2.231E-09	3.574E-09	2.852E-10	2.800E-11	5.650E-10	--
779-404 ^d		2	4.704E+07	3.414E-10	1.235E-10	1.574E-09	6.868E-10	4.747E-10	--
RFETS		258	2.054E+10	2.176E-07	-2.492E-08	-5.824E-09	3.292E-08	-1.238E-07	3.283E-05
^a Did not analyze for Pu-238 in 1998.									
^b Release points 776-205, -206, and -207 are combined through a mixing plenum and are sampled with one shrouded probe identified as 776-205.									
^c The tritium sampling occurs before the mixing plenum described in footnote b. The location names have been altered to denote them as tritium sampling points.									
^d Plenum 779-404 is a new release point for 1998.									
Note:									
EIS = Effluent Information System									
ODIS = Off-Site Discharge Information System									
Ci = Curies									
N = Number of samples analyzed									
m ³ = Cubic meters									
RFETS = Rocky Flats Environmental Technology Site									

Appendix C

Stack Data for Point Sources

Stack Data for Point Sources

Building/ Location	Height (m)	Meter (m)	Width (m)	Length (m)	Exit Velocity (m/s)	Stack Type	Vent No.
123-001 through 004*	6.00	0.61	-	-	f	Grouped	f
371-SSS	16.00	-	1.54	5.76	4.45	Penthouse	2
371-NO1/NO2 ^a	16.00	-	1.54	5.76	7.70	Penthouse	1
374-MAI	23.77	-	1.83	1.37	15.23	Penthouse	7, 8, 9
374-SPD	9.14	0.42	-	-	21.35	90°	3
444-D05	3.56	-	0.76	0.61	10.78	90°	122
444-MAI	5.90	-	2.74	2.44	6.41	90°	200
447-MAI	4.00	-	1.83	1.52	8.64	90°	201
559-561	7.00	-	2.29	1.52	13.01	Mixing Box	36
707-101/103 ^b	11.33	-	0.46	0.30	4.36	Mixing Box	36
707-102/104 ^c	11.33	-	1.37	0.91	2.89	Mixing Box	9, 10
707-105	11.33	-	1.37	0.91	5.10	Mixing Box	28
707-106	11.33	-	0.91	0.61	4.54	Mixing Box	55
707-107	11.33	-	1.60	1.07	8.41	Mixing Box	65
707-108	11.33	-	1.37	0.91	6.49	Mixing Box	75
707-R21A	13.70	1.10	-	-	11.74	Open	38
707-R21B	13.70	1.10	-	-	11.74	Open	39
707-R22A	13.70	1.10	-	-	11.74	Open	40
707-R22B	13.70	1.10	-	-	11.74	Open	41
707-R23A	13.70	1.10	-	-	11.74	Open	42
707-R23B	13.70	1.10	-	-	11.74	Open	43
707-R24A	13.70	1.10	-	-	11.74	Open	44
707-R24B	13.70	1.10	-	-	11.74	Open	45
707-R25A	13.70	1.10	-	-	11.74	Open	76
707-R25B	13.70	1.10	-	-	11.74	Open	77
707-R26A	13.70	1.10	-	-	11.74	Open	78
707-R26B	13.70	1.10	-	-	11.74	Open	79
707-R27A	13.70	1.10	-	-	11.74	Open	80
707-R27B	13.70	1.10	-	-	11.74	Open	81
707-R45A	13.00	0.84	-	-	11.74	Open	1
707-R45B	12.86	0.84	-	-	11.74	Open	2

707-R46A	12.86	0.81	-	-	11.74	Open	3
707-R46B	12.86	0.81	-	-	11.74	Open	4
771-CMA	7.67	0.61	-	-	7.60	Gooseneck	9
771-CRM8	7.82	0.45	-	-	11.54	90°	1
771-CRM10	7.25	-	0.61	0.51	2.48	90°	8
771-MAI	50.14	3.12	-	-	14.27	Open	86
774-202	7.11	-	0.91	0.61	12.55	Mixing Box	4
776-201/204/250 ^d	12.00	-	0.74	6.17	2.94	Penthouse	24
776-202	16.10	0.52	-	-	15.27	Rain Cap	17
776-205/206/207 ^e	12.00	-	1.6	1.07	10.11	Mixing Box	32
776-251	13.00	-	0.81	1.52	8.32	Wall penetration	45
776-252	13.20	-	0.91	0.56	8.42	90° Wall penetration	44
778-LDY	8.00	1.22	-	-	5.75	Open	50
779-729	26.82	0.96	-	-	9.57	Open	12
779-782	6.70	-	0.91	1.45	19.45	Gooseneck	1
779-404	9.30	-	0.94	2.44	9.02	90°	70
779-405	17.68	0.97	-	-	4.85	Open	22
790	f	f	f	f	f	f	f
865-EEE	5.66	-	1.12	1.52	7.64	90°	63,64
865-WWW	5.30	-	1.42	1.42	10.65	90°	58,59
881-MA1	12.40	2.44	-	-	5.66	Open	8
881-MA2	12.40	2.44	-	-	11.13	Open	7
881-MA3	12.40	2.44	-	-	5.28	Open	5
881-MA4	12.40	2.44	-	-	4.62	Open	6
883-AAA	7.41	-	1.32	2.50	7.53	90°	44
883-BBB	7.07	-	1.32	2.50	10.50	90°	45
883-CCC	21.34	1.22	-	-	6.40	Open	34
886-875	5.95	-	1.22	0.61	9.97	Gooseneck	15
991-985	6.25	-	1.22	0.51	11.90	Gooseneck	2
991-MAI	7.21	-	1.37	1.52	1.15	Gooseneck	41

^a371-N01/N02 combined to one penthouse.

^b707-101/103 combined into one stack.

^c707-102/104 combined into one stack.

^d776-201/204/250 combined to penthouse vent No. 24.

^e776-205/206/207 combined to penthouse vent No. 32.

^f Data not available.

*B123 demolished in 1998

Notes:

- = Not applicable

m = Meters

m/s = Meters per second

Appendix D
Meteorological Data Set

Meteorological Data Set 1998

Wind Direction	Stability Class	1.0 to 1.8 (m/s)	1.8 to 3.3 (m/s)	3.3 to 5.4 (m/s)	5.4 to 8.5 (m/s)	8.5 to 11.0 (m/s)	>11.0 (m/s)	Cumulative Fraction by Direction
N	A	0.002	0.004	0.000	0.000	0.000	0.000	0.006
NNE	A	0.003	0.010	0.000	0.000	0.000	0.000	0.012
NE	A	0.003	0.012	0.000	0.000	0.000	0.000	0.015
ENE	A	0.003	0.009	0.000	0.000	0.000	0.000	0.012
E	A	0.004	0.013	0.000	0.000	0.000	0.000	0.018
ESE	A	0.003	0.014	0.000	0.000	0.000	0.000	0.017
SE	A	0.003	0.010	0.000	0.000	0.000	0.000	0.012
SSE	A	0.002	0.004	0.000	0.000	0.000	0.000	0.006
S	A	0.001	0.002	0.000	0.000	0.000	0.000	0.003
SSW	A	0.002	0.002	0.000	0.000	0.000	0.000	0.003
SW	A	0.001	0.002	0.000	0.000	0.000	0.000	0.003
WSW	A	0.002	0.001	0.000	0.000	0.000	0.000	0.003
W	A	0.002	0.001	0.000	0.000	0.000	0.000	0.003
WNW	A	0.001	0.002	0.000	0.000	0.000	0.000	0.003
NW	A	0.002	0.002	0.000	0.000	0.000	0.000	0.003
NNW	A	0.001	0.003	0.000	0.000	0.000	0.000	0.004
N	B	0.001	0.003	0.006	0.000	0.000	0.000	0.010
NNE	B	0.000	0.004	0.004	0.000	0.000	0.000	0.008
NE	B	0.000	0.003	0.003	0.000	0.000	0.000	0.007
ENE	B	0.001	0.002	0.004	0.000	0.000	0.000	0.007
E	B	0.000	0.004	0.003	0.000	0.000	0.000	0.007
ESE	B	0.000	0.004	0.005	0.000	0.000	0.000	0.010
SE	B	0.000	0.004	0.005	0.000	0.000	0.000	0.009
SSE	B	0.000	0.002	0.002	0.000	0.000	0.000	0.004
S	B	0.000	0.001	0.001	0.000	0.000	0.000	0.003
SSW	B	0.000	0.001	0.000	0.000	0.000	0.000	0.002
SW	B	0.000	0.000	0.001	0.000	0.000	0.000	0.001
WSW	B	0.000	0.000	0.001	0.000	0.000	0.000	0.001
W	B	0.000	0.001	0.001	0.000	0.000	0.000	0.002
WNW	B	0.000	0.001	0.002	0.000	0.000	0.000	0.003
NW	B	0.000	0.001	0.001	0.000	0.000	0.000	0.003
NNW	B	0.000	0.001	0.002	0.000	0.000	0.000	0.004
N	C	0.000	0.004	0.011	0.004	0.000	0.000	0.019
NNE	C	0.001	0.002	0.006	0.001	0.000	0.000	0.010
NE	C	0.000	0.001	0.002	0.000	0.000	0.000	0.004
ENE	C	0.000	0.001	0.002	0.000	0.000	0.000	0.003
E	C	0.000	0.001	0.001	0.000	0.000	0.000	0.003
ESE	C	0.000	0.002	0.003	0.000	0.000	0.000	0.005
SE	C	0.000	0.002	0.004	0.001	0.000	0.000	0.007
SSE	C	0.001	0.002	0.003	0.000	0.000	0.000	0.006
S	C	0.000	0.002	0.001	0.000	0.000	0.000	0.003
SSW	C	0.001	0.001	0.001	0.000	0.000	0.000	0.002
SW	C	0.001	0.001	0.001	0.000	0.000	0.000	0.003
WSW	C	0.000	0.000	0.001	0.001	0.000	0.000	0.003
W	C	0.001	0.001	0.002	0.002	0.000	0.000	0.005
WNW	C	0.000	0.001	0.003	0.002	0.000	0.000	0.005
NW	C	0.000	0.002	0.003	0.002	0.000	0.000	0.007
NNW	C	0.001	0.002	0.005	0.001	0.000	0.000	0.010
N	D	0.001	0.005	0.008	0.010	0.002	0.000	0.027

Meteorological Data Set 1998

Wind Direction	Stability Class	1.0 to 1.8 (m/s)	1.8 to 3.3 (m/s)	3.3 to 5.4 (m/s)	5.4 to 8.5 (m/s)	8.5 to 11.0 (m/s)	>11.0 (m/s)	Cumulative Fraction by Direction
NNE	D	0.001	0.006	0.009	0.005	0.000	0.000	0.021
NE	D	0.001	0.004	0.004	0.001	0.000	0.000	0.010
ENE	D	0.000	0.003	0.003	0.000	0.000	0.000	0.006
E	D	0.000	0.002	0.002	0.001	0.000	0.000	0.005
ESE	D	0.000	0.002	0.002	0.000	0.000	0.000	0.005
SE	D	0.000	0.003	0.003	0.001	0.000	0.000	0.007
SSE	D	0.001	0.003	0.006	0.003	0.000	0.000	0.013
S	D	0.001	0.004	0.010	0.005	0.001	0.000	0.021
SSW	D	0.001	0.007	0.010	0.004	0.002	0.001	0.025
SW	D	0.002	0.009	0.012	0.008	0.001	0.000	0.032
WSW	D	0.004	0.012	0.012	0.013	0.004	0.002	0.046
W	D	0.003	0.011	0.009	0.016	0.013	0.014	0.066
WNW	D	0.001	0.007	0.012	0.023	0.016	0.015	0.073
NW	D	0.000	0.006	0.014	0.013	0.003	0.001	0.037
NNW	D	0.000	0.007	0.019	0.015	0.001	0.000	0.041
N	E	0.000	0.003	0.001	0.000	0.000	0.000	0.004
NNE	E	0.000	0.003	0.002	0.000	0.000	0.000	0.005
NE	E	0.001	0.002	0.001	0.000	0.000	0.000	0.003
ENE	E	0.000	0.001	0.001	0.000	0.000	0.000	0.002
E	E	0.000	0.001	0.001	0.000	0.000	0.000	0.002
ESE	E	0.000	0.000	0.001	0.000	0.000	0.000	0.002
SE	E	0.000	0.001	0.001	0.000	0.000	0.000	0.002
SSE	E	0.001	0.002	0.002	0.001	0.000	0.000	0.005
S	E	0.001	0.004	0.006	0.001	0.000	0.000	0.012
SSW	E	0.001	0.003	0.006	0.001	0.000	0.000	0.011
SW	E	0.002	0.008	0.009	0.000	0.000	0.000	0.020
WSW	E	0.003	0.011	0.006	0.000	0.000	0.000	0.020
W	E	0.002	0.008	0.004	0.000	0.000	0.000	0.014
WNW	E	0.001	0.006	0.007	0.000	0.000	0.000	0.014
NW	E	0.000	0.004	0.010	0.001	0.000	0.000	0.016
NNW	E	0.001	0.003	0.006	0.001	0.000	0.000	0.011
N	F	0.003	0.004	0.000	0.000	0.000	0.000	0.006
NNE	F	0.002	0.002	0.000	0.000	0.000	0.000	0.004
NE	F	0.001	0.002	0.000	0.000	0.000	0.000	0.003
ENE	F	0.001	0.003	0.000	0.000	0.000	0.000	0.004
E	F	0.002	0.004	0.000	0.000	0.000	0.000	0.005
ESE	F	0.002	0.003	0.000	0.000	0.000	0.000	0.005
SE	F	0.002	0.004	0.000	0.000	0.000	0.000	0.006
SSE	F	0.003	0.003	0.000	0.000	0.000	0.000	0.006
S	F	0.003	0.006	0.000	0.000	0.000	0.000	0.009
SSW	F	0.003	0.004	0.000	0.000	0.000	0.000	0.007
SW	F	0.007	0.004	0.000	0.000	0.000	0.000	0.010
WSW	F	0.006	0.005	0.000	0.000	0.000	0.000	0.011
W	F	0.006	0.007	0.000	0.000	0.000	0.000	0.014
WNW	F	0.004	0.006	0.000	0.000	0.000	0.000	0.010
NW	F	0.004	0.007	0.000	0.000	0.000	0.000	0.011
NNW	F	0.002	0.005	0.000	0.000	0.000	0.000	0.008

Meteorological Data Set 1998

Wind Direction	Stability Class	1.0 to 1.8 (m/s)	1.8 to 3.3 (m/s)	3.3 to 5.4 (m/s)	5.4 to 8.5 (m/s)	8.5 to 11.0 (m/s)	>11.0 (m/s)	Cumulative Fraction by Direction
Cumulative Fraction by Wind Speed Class		0.127	0.365	0.288	0.142	0.044	0.033	1.000

Appendix E
Model Input Summary

MODEL INPUT SUMMARY

Input Parameters for CAP88-PC for the Radionuclide Air Emission Annual Report For Calendar Year 1998

FACILITY INFORMATION

Dataset date: Model supplies date and time of dataset generation from its internal clock.
Facility: Rocky Flats Environmental Technology Site
City: Golden
State: Colorado
Zip Code: 80402-0464
Emission Year: 1998
Source Category: Former Nuclear Weapons Facility
Comments: Radionuclide air emissions for the 1998 Annual Air Emission Report required under 40 CFR 61, Subpart H

RUN INFORMATION

Run Type: Individual (Model is run to calculate dose to maximally exposed individual [MEI], not to a population.)
Distances: Varies (Each specific distance from the source to the receptor is entered; see Tables 4-2 through 4-8.)
Generate genetic Effects? YES
Create Dose & Risk Factor file? YES
Create Concentration Table file? YES
Create Chi/Q Table File? YES

METEOROLOGICAL DATA

Wind file to use: Varies (Use RFP98, wind file generated from on-Site meteorological data for calendar year 1998.)
Annual Precipitation: Varies (See Table 4-9.)
Annual Ambient Temperature: Varies (See Table 4-9.)
Height of Lid: 1,405 m (Value is an annual average of mixing heights formerly measured at Stapleton International Airport. Stapleton is the closest location that has historically measured mixing height.)

(Continued)

SOURCE DATA

June 1999

Emissions
E-1

Radionuclide Air
Annual Report

Source Type:	Area or Stack
Number of Sources:	1
Height: Varies	(0 for area source, specific stack height is entered for stack sources; see Table 4-2.)
Diameter (Stack sources only):	Varies (Specific stack diameter is entered here; see Table 4-2.)
Area (Area sources only):	Varies (Specific area of source is entered here; see Table 4-3 through 4-8.)
Plume rise:	Momentum
Exit Velocity:	Varies (0 for area source, specific exit velocity is entered for stack sources; see Table 4-2.)

AGRICULTURAL DATA

Source: Urban (The rest of the values used on this screen are defaults.)

RADIONUCLIDE LIST

Nuclide	Varies (Radionuclide used corresponds to the source and isotope being modeled.)
Ci/y:	Varies (Release rate corresponds to the source being modeled; see Tables 3-1 through 3-3.)

SIZE & CLASS DATA

Nuclide:	Varies (Radionuclide used corresponds to the source and isotope being modeled.)
Size:	Default
Class:	Default

99
99